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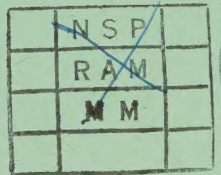
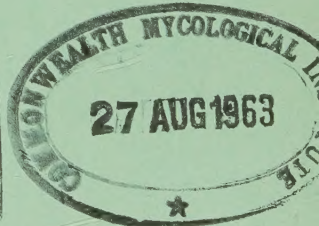
ANNUAL REPORT
1959/60

COFFEE RESEARCH STATION, RUIRU

AND

COFFEE RESEARCH SERVICES
KENYA





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INTRODUCTION

The weather in most of the coffee areas during 1959 was closer to the normal pattern than for several years. Unseasonable rain during the dry season prior to the Long Rains occurred only in the West of Rift areas. The Long Rains were generally late and were succeeded everywhere by prolonged dry weather. In the Trans Nzoia and East of Rift districts the five months up to the end of October were especially dry. Consequently the quality of the early crop, of which there was an unusually high proportion, was adversely affected, although earlier ripening undoubtedly alleviated crop strain on the trees.

Except in Nyanza the relative absence of infective periods before the Long Rains was expected to arrest the recurring epidemic of Leaf Rust, which has been so prominent a feature of the past four years. In the lower zones East of the Rift, however, Rust caused severe leaf-drop before the onset of the Short Rains. As a consequence of diminished sources of infection the build-up of disease was comparatively less at this period.

Whilst Coffee Berry Disease was more widespread in Nyanza the dry weather favoured a decline of infection elsewhere. During the year the disease advanced in Central Province and became established in the most southerly locations of Meru district.

Rainfall at the Department's Coffee Stations during 1959

	A	B	C	D	E	F	G	H
January	1.33	0.71	1.55	0.24	2.82	1.16	No record	No record
February	0.21	0.61	1.07	2.63	4.18	2.11	,,	5.17
March	3.43	5.01	3.33	4.03	18.10	4.42	,,	8.39
April	3.98	3.38	4.08	5.10	10.87	7.15	,,	9.35
May	8.69	3.44	9.04	3.55	4.97	5.27	2.90	7.28
June	0.07	0.00	0.00	1.95	4.40	0.08	0.00	1.41
July	1.26	1.08	0.17	3.32	1.02	1.66	0.42	2.89
August	0.68	1.81	0.36	3.12	6.07	1.19	0.42	4.50
September	0.70	0.49	0.04	2.18	8.86	1.24	1.97	2.28
October	0.48	1.46	0.52	4.65	5.11	1.06	1.00	3.21
November	10.01	11.37	8.04	3.56	5.90	11.58	17.36	7.07
December	2.86	2.22	2.75	0.29	2.19	2.87	7.11	3.19
Total	33.70	31.58	30.95	34.62	74.49	39.79	(31.18)	(54.74)
No. of days Total	120	110	88	135	182	132	(72)	(123)
Means and number of years	38.98 15	37.11 34	37.19 20	45.57 26	73.20 16	(figures not available)		

A = Coffee Research Station, Ruiru
B = Scott Agricultural Laboratories, Kabete
C = North Kitito Estate, Makuyu
D = Kitale Experimental Station
E = Experimental Farm, Kisii (Coffee Research Sub-station from 10.12.59)
F = Upper Kiambu Coffee Research Sub-station
G = Mariene Coffee Research Sub-station, Meru
H = Koru Coffee Research Sub-Station

The post of Agricultural Chemist became vacant on the 15th March when Mr. J. B. D. Robinson transferred on promotion to become Senior Research Officer at the Coffee Research Station, Lyamungu, Tanganyika. By the end of the year under review arrangements had been completed for appointment of additional staff for the Entomology Section, to expand the range of research upon insect pests.

The expansion of other sections was completed with the appointment of Messrs. Wormer, Firman, Lamb and James. Mr. Coltman joined the staff from Kiambu in September.

The Coffee Berry Disease Research Unit has continued its study of the epidemiology and control of the disease and, early in the year, undertook a similar programme of investigation into the chemical control of Leaf Rust. Detailed advice for control of both diseases, based upon field evidence, was formulated towards the end of the year.

In the field of processing research studies of the problem of artificial drying were brought to a successful conclusion and comprehensive advice was issued to the industry prior to the departure in April of Mr. J. F. McCloy, Senior Scientific Officer, E.A.I.R.O. Whilst subsidiary aspects of the problem require further investigation the major findings have shown that artificial drying techniques can be employed, whereby no loss of quality is incurred, provided that the coffee is exposed to the bleaching effect of sunlight for a specified period during the process. No economical substitute for the bleaching effect of the blue rays of sunlight is in sight, however. Methods of drying as an emergency measure have been evolved to reduce degradation of quality to a minimum. Since April the programme has been continued by Mr. C. L. Gough, Assistant Agricultural Officer, with particular reference to time and temperature studies of ventilated bins and, in collaboration with Mr. A. E. Wootten, Chemist of E.A.I.R.O., a new attack was launched on the problem of onion flavour.

The Entomologist's attention was directed mainly to investigating three of the major pests which are currently causing concern in the industry. Some useful progress was made in studies of the bionomics of Leaf Miner, Tip Borer and Antestia. The approach adopted aims to discover ways of achieving lasting control without frequent resort to chemical sprays, which are apt to upset the balance of control of other pests.

Mr. Robinson's research in Agricultural Chemistry has been concentrated on soil fertility problems, in particular the influence of Napier grass mulch, manurial and cultural treatments upon soil fertility. With the appointment of a trained technologist the research programme of foliar analysis by spectrochemistry was begun towards the end of the year.

Of the many and varied cultural problems under investigation experiments concerning grass mulch, cattle manure and nitrogen fertilisers have been prominent for the past ten years. At the end of the 1958/59 season an appropriate point was reached for assessing the results obtained: a summary of their investigations and their conclusions was written as a scientific paper and articles containing practical recommendations were published in *Kenya Coffee*.

After his arrival in July the Pathologist devoted most of his time to the condition known as Stem-pitting. A Colony-wide survey was undertaken in the last quarter of the year with the object of clarifying the circumstances surrounding its incidence and severity. As a result of the survey it was possible to formulate a research programme with precise objectives.

The study of coffee physiology was separated from pathology upon the appointment of Dr. T. M. Wormer in April. Of the many major problems awaiting study those concerned with water relations and carbohydrates in the tree have particular prominence. After preliminary studies of techniques and method had been concluded a comprehensive programme was planned and initiated, incorporating these subjects as major lines of research.

Results accruing from the programme of variety trials throughout the coffee areas are now of considerable value in guiding the expansion of coffee acreage on plantations and peasant holdings, especially in relation to disease and drought resistance. The year under review was marked by an accelerated flow of such information.

A substantial demand for coffee seed continues at the level attained in 1958/59. Issues of seed were made totalling 6,008 lb. to plantations, 4,226 lb. to African districts and 113 lb. to other territories, making a total of 10,347 lb. of seed.

ADVISORY AND EXTENSION SERVICES

In most coffee-growing districts an upward trend in yield has prevailed since 1955 as a result of improved cultural methods and more intensive treatment. This feature combined with an expanding plantation acreage and accelerated progress in African areas demands a corresponding ability to convey the results of research to the grower.

The level of the advisory and extension service reached in 1958 was maintained and improved in certain directions. In addition to a considerable volume of advice provided through the medium of correspondence and telephone the means by which information and advice has been disseminated to growers is illustrated by the following:—

General Advisory Service. Mr. Cottington operates in the East of Rift, Rift Valley and Nyeri districts. He visited 284 plantations and made three tours in the Rift Valley and three in Nyeri district during the year. Mr. Goodwin continued to serve as advisory officer in Limuru and Upper Kiambu districts and took over the advisory work in Kabete district. West of the Rift Valley Mr. de Vink is responsible for routine advice to growers in the Trans Nzoia, Uasin Gishu and Kaimosi districts, whilst Mr. Toomey operates in the Nyanza, Elburgon and Ravine areas. Advice on specialised subjects has been provided by the appropriate sections, the soil analysis and entomology routine services being continued throughout the year. A large number of estates have taken advantage of the Irrigation Advisory Service and the feasibility of the service being extended to the Rift Valley and Nyeri areas is being explored.

Tours. Apart from the district tours undertaken by Messrs. Cottington and Hanger an appreciable number of tours was undertaken by other officers: Messrs. Jones, Robinson, Crowe, Wallis, Wormer and Firman made a total of 27 tours to districts during the year.

Field Days. The coffee trials formed part of a field day held on the Kitale Station in September. In October a field day was arranged at the Coffee Research Station for a group of planters from Donyo Sabuk. Field days were arranged for parties from Nyasaland, Tanganyika and the Coffee Trade Representatives from Europe in January.

Lectures. The annual coffee lectures were delivered to students at the Egerton Agricultural College, by Messrs. Jones and Robinson in May and again in February this year by Messrs. Robinson and Wallis. Officers discoursed to district groups in Kiambu, Ruiru and Thika and at field meetings of Young Farmers Clubs and the R.A.S.K.

Courses. Several courses were arranged for coffee officers, instructors, groups of African growers and individual plantation managers. Mr. Hanger and other officers participated in courses held in districts for coffee officers and instructors. In addition 19 headmen were given courses of training in pest control at the Coffee Research Station.

Shows. Exhibits were staged at the R.A.S.K. show at Mitchell Park and by Mr. de Vink at the Kitale show in October.

Publications. The third separate Annual Report, for the year 1958/59, was compiled and published in July 1959. A folder of advisory leaflets on coffee pests was compiled by the Entomologist for issue to plantation managers and coffee officers. By the close of the year suitable photographic material had been collected for the Pests and Diseases brochure. Although much time and effort have been expended on this project there is reason to believe that the publication, when complete, will be a valuable addition to our advisory literature.

The Better Coffee Farming Notes in *Kenya Coffee* were maintained as a means of distributing advice and information to growers.

PUBLICATIONS

The following articles were published in *Kenya Coffee*, the Coffee Board of Kenya monthly bulletin:—

1959. VOL. XXIV

May	Annual Report for Coffee Team Services, by P. A. Jones.
August	"General Nitrogen Fertilizer Recommendations for Mature Coffee," by J. B. D. Robinson.
September	"Root Rot of Coffee and Ring-Barking of Shade Trees," by R. W. Rayner (formerly Plant Pathologist/Physiologist, Coffee Services).
October	"Urea Sprays in Coffee: Leaf Damage associated with Biuret Contamination and Spray Strength," by J. B. D. Robinson and (Miss) G. S. Harcombe.
October	"The Yellow-Headed Borer," by T. J. Crowe.
November	"Coffee Pest Calendar," compiled by T. J. Crowe.
November	"Chemical Weed Control in Coffee," by J. B. D. Robinson.
December	"Recommendations for the Application of Cattle Manure to Coffee," by J. B. D. Robinson and J. A. N. Wallis.

1960. VOL. XXV

January	"Recommendations for the Application of Organic Mulches in Coffee," by J. B. D. Robinson and J. A. N. Wallis.
February	"Notes on the Diagrams Illustrating Coffee Yields in Kenya (Excluding African Area Production)," by J. B. D. Robinson.
March	"Amber Beans," by J. B. D. Robinson.

Articles published in other journals during the year were as follows:—

Robinson, J. B. D.

Allen, M. de V. and Gacoka, P. — The Determination of Soil Nitrates with a Brucine Reagent. *The Analyst*, 1959, **84**, 635.

Wallis, J. A. N. — Chemical Taints in Arabica Coffee. *World Crops*, 1959, **11**, 321.

FIELD INVESTIGATIONS

CULTIVATION TRIAL

This trial has now run for 13 years and although it was reduced in scope and extent in 1952 and again in 1954 it has provided results of great interest and consistency. The principal treatments in the experiment have been provided by the factorial combination of three systems of weed control effected by three different implements. Each main plot is split to allow the testing of the Athi Plains cattle manure. This is sun-dried material collected from uncovered cattle enclosures. The weed control policies refer to management during the two periods of rain which occur each year. The season between late March and early June is called the Long Rains and the Short Rains fall between the end of October and early December. Between the rains all plots are thoroughly weeded.

TABLE I

Yield Summary 1952-1959

(Cwt. clean coffee per acre per annum)

Manure	*No Manure*	*1 × 4-gall. tin/ tree Athi Plains manure*	*Mean*	*Least significant difference*	
				p=0.05	p=0.01
1959	8.24	9.61	8.93	1.24	1.68
1952-1959	7.46	8.18	7.82	0.44	0.60

1952-1959 *Implements*	*Weeding policy during the Rains*			*Means for Implements*
	Wo Clean weeded	*W1 Weeds slashed*	*W2 Tall weeds*	
To Forked hand hoe	9.76	7.34	6.23	7.78
T1 Disc harrow	9.53	7.72	6.52	7.92
T2 Mouldboard plough	9.02	8.26	6.00	7.76
Means for weeding policies	9.44	7.77	6.25	7.82
Least significant difference between marginal means				
p = 0.05				0.70
p = 0.01				0.97
p = 0.001				1.33

In 1959 only the cattle manure affected the yield of coffee significantly in raising production by 1.37 cwt. per acre. The main results of this trial are summarised in the mean yields for the eight crops 1952-1959. Although there is no difference of interest between the implements, the weeding policies have had a marked effect on the yield of coffee. If instead of keeping the coffee clean weeded the weeds have only been cut back whenever they were a foot high the coffee crop has been depressed by 18%. Failure to weed at all during the rains has increased this loss to 37%.

On the Wo plots which have been clean weeded for 13 years, the soil structure has been affected adversely. The physical examination of soil samples collected in July 1957 showed that the W2 (Tall weeds) plots were in a better condition than the Wo (Clean weeded) plots in the following respects.

	Wo	*W2*	*Difference*	*Statistical significance*
Total Pore space	64·35%	66·84%	2·49%	p=0·05
Static percolation inches/hour	13·87	22·93	9·06	p=0·05
Rainfall acceptance	74·85%	87·52%	12·67%	p=0·01

In spite of the poorer soil structure on the clean weeded plots they have produced 51% more crop than those in which the coffee has to compete with tall weeds during the Rains.

Soil samples were collected from this trial in 1959 for chemical determinations. Although the different weeding treatments have resulted in very marked and significant yield differences over the period 1947-1959, no statistically significant differences between these treatments are apparent in the chemical analyses. This suggests that soil moisture is the factor of principal importance in explanation of the yield differences recorded in this trial. Undoubtedly weed growth does compete for plant nutrients during the Rains when the different weeding treatments are carried out, but these nutrients are not removed from the soil permanently because the weed growth eventually decomposes *in situ* and the plant foods are returned to the soil. Thus it is the time when this competition for nutrients occurs which is probably the important factor, and since the soil samples were collected in a dry season deficiencies in total nutrients were not detected.

TABLE II

Summary of the Chemical Analysis of Soil Samples Collected in March 1959

	pH			*K Meq. %*			*Ca Meq. %*			*Mg Meq. %*			*P ppm.*		
Depth of Samples	*0-8″*	*8-16″*	*Mean*	*0-8″*	*8-16″*	*Mean*	*0-8″*	*8-16″*	*Mean*	*0-8″*	*8-16″*	*Mean*	*0-8″*	*8-16″*	*Mean*
Weeding Policy in Rains															
Wo Clean weeding	5.7	5.6	5.6	1.6	1.3	1.4	6.1	3.7	4.9	3.1	2.7	2.9	20	16	18
W1 Weeds slashed	5.5	5.4	5.4	1.7	1.2	1.4	4.7	2.7	3.7	3.1	2.2	2.7	16	12	14
W2 Tall weeds	5.7	5.5	5.6	1.8	1.1	1.4	5.4	2.9	4.2	3.3	2.5	2.9	19	12	15
	No significant difference														
Athi Plains Manure/ tree															
No manure	5.5	5.5	5.5	1.4	0.9	1.2	5.2	3.3	4.3	3.0	2.5	2.8	15	14	14
1 × 4-gall. tin	5.8	5.4	5.6	2.0	1.5	1.8	5.4	2.9	4.2	3.3	2.4	2.9	21	13	17
Least significant difference															
p=0.05			N.S.			—			N.S.			N.S.	—	—	—
p=0.01						—							1	1	1
p=0.001						0.5							—	—	—

See page 11 for introduction.

Evidence that uptake of plant nutrients in the weed growth, and eventual return after decomposition, has altered the proportion of potassium in the soil is provided by the differences between topsoil and subsoil means for exchangeable potassium. The longer the weeds remain in the plot before cutting (Wo<W1<W2) the higher the topsoil content of potassium and the lower the subsoil value. Since these differences are not statistically significant it is only possible to suggest that they represent a true effect of the transfer of potassium from the 8″-16″ to the 0″-8″ level of soil by passage through the weed growth.

The application of Athi Plains manure to these plots has increased significantly the potassium and the phosphorus levels in the top 16″ of the profile. The phosphorus values show that the increase attributable to the use of cattle manure has all occurred in the 0″-8″ layer of topsoil.

ROTAVATOR TRIAL

Preliminary work in 1952 led to the development of a modification to a tractor mounted "Howard Rotavator" so that it would produce a very coarse tilth similar to that resulting from the use of a forked hand hoe. The depth of cultivation was limited to 2½″-3″ so as to minimise damage to coffee roots. Ten-inch stirrup-shaped tines were fitted to the rotor and the gearing and tractor speed were determined at which the roughest tilth was produced. The optimum distance along the ground between cuts was found to be about eight inches.

At the end of 1952 a yield recorded trial was designed to compare the long-term effects of rotary cultivation and weeding with a forked hand hoe. These implements have now been used for six years, with and without mulch, to carry out two weeding régimes. The coffee has either been cultivated

whenever the weeds reached more than 3″-4″ in height, or at the end of each Rains and occasionally to turn in weeds produced by out of season rainfall. The clean weeding has required 5-6 cultivations per year and 34 treatments between December 1953 and December 1959 and over the same period 3-4 weedings a year or 21 in all have been carried out on the other treatment.

It is intended to publish a full report of this investigation elsewhere. Only the salient results are given in Table III.

TABLE III

Yield Summary 1953-1959

(Cwt. clean coffee per acre per annum)

	No Mulch	*Mulch*	*Mulch Response*	*Responses to Mulch*	
				Forked hand hoe	*Modified Rotavator*
Clean Weeding	6.82	7.92	+1.10	+0.54	+1.65
Weeding at the end of each Rains	5.61	7.27	+1.66	+1.89	+1.43
Effect of weeds	−1.21	−0.65			
Least significant difference					
p = 0.05			0.49	0.70	
p = 0.01			0.73	1.03	
p = 0.001			1.13	1.59	
Coefficient of Variation			4.27%		

The beneficial effect of mulching and the harmful influence of weed competition on coffee production are shown clearly in the mean annual yields for the six crops. The role that mulch can play in suppressing weed growth is illustrated by the smaller response to frequent weeding in the presence of mulch than in its absence.

A curious result is that there has been no significant response to mulch where the forked hand hoe has been used frequently although the coffee forked less often and that "rotavated" at either frequency has shown a substantial response to mulch.

Soil samples have been collected by the Physics Division of the East African Agricultural and Forestry Research Organisation on several occasions during the course of this trial. A study has been made of the effect of the various cultural treatments on the soil structure and its ability to accept rainfall without the surface capping. From the samples collected in January 1960 it has been concluded that soil structure has been well maintained over the six years provided that alternate row mulching is associated with the use of the modified "Rotavator". In the absence of mulching the Rotavator has damaged the soil more than a forked hand hoe, and nearly 30% of a heavy storm might be expected to run off whereas with mulch applied to alternate inter-rows in alternate years all but 6% of a 1-inch test storm in ten minutes was able to enter the soil.

IRRIGATION TRIAL

This trial was commenced in 1956 with the main object of determining the season at which irrigation was most effective in improving the yield and quality of coffee (Jones and Wallis, 1957). At the end of the Short Rains (a) (November-December) and Long Rains (b) (April-May) adequate water is usually available in the streams to permit extensive irrigation. During August (c) stream flow is normally much reduced, but this month is important because the crop is generally maturing rapidly. In this experiment irrigation is carried out at each and all combinations of the three periods. An extra treatment, designated X, is incorporated in the trial by which irrigation is applied whenever the soil moisture deficit is estimated as being greater than two inches.

Pereira's (1957) local adaptation of Penman's principles has been used to determine the amount of water to apply on each occasion. The quantity is determined which will bring the top ten feet of soil to Field Capacity. As a further control on these calculations BTL gypsum blocks have been installed at various depths between one and ten feet from the surface. The Physics Division of the East African Agriculture and Forestry Research Organisation has maintained a detailed interest in this trial and soil samples for moisture determination have been collected on one or two occasions each year.

TABLE IV

The Annual Soil Moisture Balance on the Unirrigated Plots for the Period of the Irrigation Trial 1956-1959.

(All data in inches of water)

Year	*Rainfall*	*Open tank evaporation*	*Evapo-transpiration Estimate*	*Annual change in moisture storage*	*Drainage loss*	*Net evapo-transpiration*	*Limitation of evapo-transpiration by dry soil*	*Effective rainfall*
	R	*Eo*	*fEo*	*S*	*D*	*En*	*fEo-En*	*R-D*
1956	36.98	53.67	33.85	+3.10	Nil	33.85	Nil	36.98
1957	58.66	52.63	32.85	+6.07	19.74	32.85	Nil	38.92
1958	55.13	55.98	36.61	—5.84	24.36	36.61	Nil	30.77
1959	33.70	61.44	37.36	+1.59	Nil	32.11	5.25	33.70

The annual soil moisture balances for the period of this trial are presented in Table IV. The rainfall total in 1959 was about 5″ less than the 15-year mean, but the open-pan evaporation was normal for the district. This draws attention to the notably low evaporation totals for the first three years of the trial. Between 1.1.59 and 1.1.60 the available water in the top ten feet of soil increased by 1.59 inches and, unlike the years 1957 and 1958, no water drained to below ten feet. The full annual rainfall during 1959 may be considered as having been available to the coffee, unlike part of the rain which fell in the previous two years and which drained to depths beyond the usual root range of coffee grown in Kenya.

TABLE V

Quantity in Inches of Irrigation applied by Overhead Sprinkler during 1958-1959 Season

(Half these quantities were applied to the ground irrigated plots)

Treatments in factorial combination	*Supplement to Short Rains 1958 (a)*	*Supplement to Long Rains 1959 (b)*	*August 1959 application (c)*	*Total for Season*
(1)	—	—	—	0.0
a	8.0	—	—	8.0
b	—	7.5	—	7.5
ab	8.0	4.5	—	12.5
c	—	—	9.0	9.0
ac	8.0	—	9.0	17.0
bc	—	7.5	4.5	12.0
abc	8.0	4.5	4.0	16.5

Extra Treatment X Dec. 1958 3.0: 1959 Jan. 3.0 Feb. 3.0 May 4.0 June 2.0 Sept. 4.0 = 19.0

The amounts of irrigation applied on this trial during the year in which the 1959 crop developed are summarised in Table V. These are the quantities put on to the coffee by sprinkler irrigation. To the plots irrigated by water piped to basins beneath each tree irrigation was at half this rate per acre. For the main trial quantities totalled between 7.5 inches and 17.0 inches for the full year and 19.0 inches was put on to the X plots in six applications.

TABLE VI

Estimated Soil Moisture Deficits on the first day of each month of 1959

(The quantity of water in inches necessary to bring the first 10 ft. of soil to Field Capacity)

Irrigation Régime	*January*	*February*	*March*	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*November*	*December*
(1)	7.82	9.34	12.06	11.12	11.07	5.70	8.45	9.56	11.38	12.13	12.44	5.68
a	3.04	4.56	7.77	7.91	7.86	2.49	5.24	6.35	8.17	10.10	12.25	5.49
b	7.82	9.34	12.06	11.12	11.07	1.70	0.95	2.06	3.88	5.81	8.62	1.86
ab	3.04	4.56	7.77	7.91	7.86	2.49	0.88	1.99	3.81	5.74	8.55	1.79
c	7.82	9.34	12.06	11.12	11.07	5.70	8.45	9.56	2.38	4.31	7.12	0.36
ac	3.04	4.56	7.77	7.91	7.86	2.49	5.24	6.35	0.67	1.70	4.51	0.00
bc	7.82	9.34	12.06	11.12	11.07	1.70	0.95	2.06	0.54	2.47	5.28	0.00
abc	3.04	4.56	7.77	7.91	7.86	2.49	0.88	1.99	0.54	2.47	5.28	0.00
X	3.04	1.56	1.77	1.94	1.86	0.00	0.75	1.86	3.68	1.70	4.51	0.00
Percentage of total picked	0	0	0	0	3	4	29	14	17	9	24	0

The estimated effects of the various irrigation treatments on the soil moisture status are summarised in Table VI, which also shows the estimated water deficit in unirrigated soil. In all cases the figures represent the number of inches of water necessary to bring the top ten feet of soil to Field Capacity. It can be seen that the various irrigation treatments produced distinctly different moisture régimes although the heavy rainfall during November ensured that by 1st December, 1959, only the (a) and Control plots were short of water. The (X) plots were kept well watered but too great a deficit was allowed to build up during December 1958, August 1959, and possibly October 1959, though in the last instance the Short Rains appeared imminent and irrigation unwarranted. At the bottom of Table VI the percentage of the total weight of crop picked is shown for each month. It is notable that 50% of the crop had been picked by the end of August. Two heavy pickings occurred in July, and in November the last 24% of the crop was gathered in two pickings and a final stripping.

Data are presented in considerable detail in Tables VII, VIII and IX to indicate the full range of assessments normally made on an important trial. Each figure in Table VII is based on values from 12 plots of ten trees each and can be considered about as accurately determined as is possible with results from a single year. The Co-efficient of Variation for the analysis of clean coffee yields was 8.76% and for the yields of Grade 'A' coffee the Co-efficient was 11.89%.

The yields of cherry and clean coffee were exceptionally high by local standards but no significant difference can be detected between treatments or groups of treatments. The yields of cherry and the yields of clean coffee determined from one-tenth sample of cherry taken at each picking from each plot showed a very consistent relationship unaffected by treatments. The mean cherry : clean coffee ratio of 6.14 is approximately the average value of 6 which is accepted as sound for local conditions.

The percentage of Grade 'A' coffee produced under the various régimes shows some slight variation between treatments. 38.20 per cent of the coffee from the unirrigated trees was of Grade 'A', while 48.95% of the yield from the X plots came into this grade. Notwithstanding this trend the total weight of Grade 'A' coffee did not differ significantly with the various irrigation treatments.

In the final column of Table VII the hulling loss percentages are shown for each treatment between which there are no significant differences. These values are about 8% greater than the loss in hulling recorded in commercial out-turns because the experimental samples included a one-tenth of the final strippings which were not wet processed, but were merely sun dried as "buni" (em coco).

TABLE VII

Summary of Yields from Main Treatments, 1959

Treatments: Season of Irrigation	*Cherry cwt. per acre*	*Cherry: Clean ratio*	*Clean Coffee cwt. per acre*	*Grade 'A' %*	*Grade 'A' cwt. per acre*	*Hulling Loss %*
(1) Control	121.62	6.10	19.95	38.20	7.62	28.18
a. December	111.57	6.12	18.24	42.00	7.66	27.73
b. June	116.14	6.08	19.10	39.11	7.47	28.22
ab.	114.54	6.14	18.65	44.83	8.36	27.98
c. August	124.95	6.21	20.12	42.10	8.47	28.07
ac.	111.20	6.15	18.07	43.39	7.84	27.71
bc.	126.48	6.21	20.38	41.46	8.45	27.92
abc.	111.50	6.15	18.14	43.27	7.85	27.85
X as necessary	107.39	6.09	17.63	48.95	8.63	28.00
Overall means including X	116.15	6.14	18.92	42.59	8.04	27.96
			No significant difference			
Factorial Combination only (excluding X)						
— a	122.30	6.15	19.89	40.22	8.00	28.10
+ a	112.20	6.14	18.28	43.37	7.93	27.82
— b	117.33	6.14	19.10	41.42	7.90	27.92
+ b	117.17	6.15	19.07	42.17	8.03	28.00
— c	115.97	6.11	18.99	41.03	7.78	28.03
+ c	118.53	6.18	19.18	42.56	8.15	27.89
			No significant difference			

TABLE VIII

Summary of Yields from Subsidiary Treatments

(Cwt. of clean coffee per acre)

	Nitrogen Fertilizer		*Means for Irrigation Method*
	Nil	*100 lb. Urea per acre*	
Overhead irrigation	18.67	19.67	19.17
Ground irrigation	18.85	18.50	18.67
Means for Fertilizer treatment	18.76	19.08	18.92
	No difference significant		

As subsidiary treatments to the main trial overhead and ground irrigation are compared and as a further subdivision the importance of nitrogen fertilizer is tested. Table VIII summarises the 1959 results from these two pairs of comparisons and shows that there was no difference of statistical significance.

TABLE IX

Summary of Quality and Growth Assessments 1959

Season of Irrigation	*Quality*			*Growth in cms.*	
	Means of 10 scores		*Means of 6 scores*	*Means of 360 Dec. 1959*	
	Raw + Roast Max. 20	*Liquor Max. 10*	*Classification*	*Length of lowest primary*	*Vertical growth in 1959*
(1) Control	10.4	4.0	4—	96.98	42.88
a. December	11.4	4.5	3—	97.21	41.33
b. June	11.8	4.0	3—	93.91	38 41
ab.	10.7	4.3	4	97.84	45 03
c. August	11.8	4.7	3—	95.60	42 69
ac.	11.2	4.7	4	97.39	43 22
bc.	11.1	4.5	4	96.03	42.73
abc.	11.0	5.0	4	99.65	39.71
X As necessary	11.2	5.0	3—	100.73	48.68
Overall means including X	11.2	4.5	—	97.26	42.74
	No significant difference				
Factorial Combination only (excluding X)					
— a	11.3	4.3		95.63	41.68
+ a	11.1	4.6		98.02	42.32
— b	11.2	4.5		96.80	42.53
+ b	11.2	4.4		96.85	41.47
— c	11.1	4.2		96.48	41.91
+ c	11.3	4.7		97.17	42.09
	No significant difference				

In order to study the importance of irrigation as a means of maintaining and improving the quality of high yielding coffee numerous samples of parchment coffee were collected on four occasions during the 1959 season. A summary of the assessments is given in Table IX. The general level of quality was disappointing but this was not very surprising when it is realised that the mean yield for the trial approached one ton of clean coffee per acre. For the 'Raw' and 'Roast' appearance the average description was 'Fair to Good' and the average liquor report evaluation was 'Fair'. The overall classification was never better than Class 3, and frequently considerably lower. The irrigation treatments failed to influence significantly the 'Raw' + 'Roast', 'Liquor' or the Class description of the coffee.

After the final stripping in 1959 the length was measured of each of the three 'heads' on each tree in the irrigation trial. By subtracting from these values the length of head known to have been left when pruning a year earlier an estimate was made of the vertical growth of each 'head' during 1959. The values shown in Table IX are each based on 360 measurements yet fail to show any significant difference between treatments. After pruning in 1959 the lowest primary on each of the 3,240 'heads' was measured in order to obtain an estimate of the spread of each tree, but no significant effect of irrigation could be detected. Despite this evidence in November 1959 it was apparent that the unirrigated plots were the least vigorous and carried fewer leaves than any of the irrigated plots. Secondary growth was prolific on irrigated plots but almost absent on the control plots. Sampling techniques are under study to provide objective data on foliation and general vegetative growth of coffee trees.

In February 1959 soil samples were collected from unirrigated plots and from the X plots which had been kept well watered at all times. A summary of the analyses made is given in Table X.

TABLE X

Analysis of Soil from X Plots Receiving 19 inches Irrigation in 6 Applications

	pH			*K* *Meq. %*			*Ca* *Meq. %*			*Mg* *Meq. %*			*P* *ppm.*		
Depth of Sample	*0-8"*	*8-16"*	*Mean*	*0-8"*	*8-16"*	*Mean*	*0-8"*	*8-16"*	*Mean*	*0-8"*	*8-16"*	*Mean*	*0-8"*	*8-16"*	*Mean*
Method of Irrigation															
No irrigation	5.6	5.3	5.4	2.0	1.2	1.6	5.4	2.1	3.8	2.4	1.8	2.1	15	12	14
Overhead	5.7	5.4	5.6	2.2	1.7	1.9	5.3	2.7	4.0	3.3	2.5	3.0	20	15	17
Ground	6.0	5.6	5.8	2.4	1.5	1.9	5.6	2.1	3.8	3.1	1.8	2.5	20	14	17
Fertilizer application															
Nil			5.5			1.7			3.4			2.5			15
100 lb. urea per acre			5.7			2.0			4.3			2.6			16
Least significant difference p=0.01			0.1			0.3			0.8			N.S.			N.S.

See page 11 for introduction.

Although none of the irrigation treatment means differ from one another significantly there is a tendency for the pH value and the levels of exchangeable magnesium, potassium and phosphorus to be higher in the irrigated soil. If these turn out to be real effects they may be attributable to the use of river water for irrigation and the more rapid decomposition of the grass mulch when frequently watered. Where urea had been applied at 100 lb. per acre in April 1958 and 1959 the levels of pH, exchangeable potassium and calcium were all raised significantly by the fertilizer.

Four crops have now been recorded from the irrigation trial to which the first treatments were applied in May 1956. In no season has there been a significant difference between treatments although the design of the trial ensures that a difference of 15% could be detected in 1959 with a fair degree of confidence (p=0.05). The 1956 irrigations may have been too late to be useful to the current crop and failed to influence the 1957 yields because of the very heavy rain which fell in January that year. For the whole of 1957 and the first eight months of 1958 natural rainfall was so great that at the specified times irrigation was unnecessary to maintain soil moisture at Field Capacity to a depth of ten feet. From the end of the Short Rains 1958 considerable quantities of water were applied to the various plots (Table V) but had little or no effect on the yield or quality of coffee produced in 1959. The irrigation appeared to improve the vegetative vigour of the trees but attempts to measure this effect were unsuccessful in defining this benefit which however should be reflected in the yield of coffee picked in 1960.

From these results it might be deduced that irrigating coffee under local conditions is ineffective, yet such a conclusion is untenable in the face of ample evidence to the contrary. For many years field trials have shown the importance of cultural measures to improve the soil moisture status under coffee. For instance, clean weeding at all times has been shown to raise yields by as much as 40% (Pereira and Jones, 1954) and the value of grass mulches has been reported on many occasions (Jones, *et al.*, 1960). There is an increasing volume of evidence from farmers on the great value of irrigating coffee in Kenya (Robson, 1953, Shields, 1954, Littlehales, 1960), and from other territories come data showing that coffee yields can be greatly improved by irrigation (Medcalf, 1958).

The failure of this trial to produce distinct results may be attributed to some or all the following factors:

(1) Coffee is a perennial crop on which some cultural measures take several seasons to exert their full effect.

(2) Between January 1957 and August 1958 soil moisture was adequate on all plots as a result of heavy rain. Irrigation was not applied during this period, so differential yields could not be expected.

(3) By August 1958 all the wood had been formed on which the 1959 crop could be borne. Subsequent dry conditions failed to depress the yield of coffee but reduced the amount of secondary vegetative growth on which the 1960 crop might be carried.

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ANALYSIS OF SOIL SAMPLES TAKEN FROM COFFEE TRIALS

With the co-operation of the Chemistry Section of the Scott Agricultural Laboratories, Nairobi, soil samples have been collected from plots in most of the manurial and cultural coffee trials on the Research Station, and have been analysed chemically. This work was undertaken to examine (1) the influence of manurial and cultural treatments on the chemical analysis of the soil, and (2) to examine the analytical data in relation to the yield response obtained to different treatments.

Whilst a considerable amount of detailed information has been forthcoming about the effect of treatments on the chemical analysis of the soil, little headway has been made in obtaining correlations between soil analysis data and yield responses to different treatments in the several trials which have been investigated.

Soil samples were collected at 0-8″ and 8″-16″ depths; field trial plot sizes vary from 8 to 20 trees (except in the magnesium survey trial which has only two trees) and three sets of borings have been bulked, mixed and sub-sampled for analysis from each plot. Where an inter-row mulch treatment was present separate samples were taken in each plot from beneath the mulch and from the bare soil.

The soil samples were analysed both chemically and biologically (growth of *Cunninghamella Blakesleeana* under standard conditions of temperature and moisture) but the very variable results obtained with the latter technique makes it extremely difficult to interpret the results. Therefore the chemical analyses are summarised for individual trials but the biological results for nitrogen and phosphorus are summarised generally for several trials together and results for other elements are only given for Manurial Trial V. The biological phosphorus analysis results do show some consistent relationship with the chemical values, particularly in the 0-8″ topsoil samples but the absence of any specific yield response by the mature coffee tree to this element does not allow a relationship to be established between crop yields and the results of biological analyses.

The results of biological analysis of soil samples from the cattle manure treated and untreated plots in four of the trials are summarised in Table XI. The results are consistent in showing that higher levels of nitrogen and phosphorus were available to the test fungus following treatment of the soil with cattle manure. However, the results for nitrogen are difficult to interpret in detail as a basis for advisory work as the percentage growth is very variable between trials. The phosphorus values are also variable between different trials.

Since the cattle manure treatments have increased yields significantly in most of these trials it is thought that this may be attributed to the increased supply of nitrogen. The phosphorus applied in the form of cattle manure may be important, but this is less likely in view of the lack of yield response to inorganic phosphorus fertilizer in the early years of Manurial Trial I and in the present Manurial Trial II (Table XIV).

TABLE XI

The Effect of Cattle Manure Treatments on the Biological Analysis Results for Nitrogen and Phosphorus

Trial	*4-gall. tin/tree*	*Nitrogen*		*Phosphorus*	
		*degrees**	%†	*degrees*	%
Cultivation					
No manure	Nil	26.6	20	13.3	5
Athi Plains Manure	1	32.8	29	28.8	23
Least significant difference		N.S.			
p = 0.001	—		—	10.7	—
Mulch					
No manure	Nil	7.5	2	19.7	11
Composted manure	1	36.4	35	29.5	25
	No significant difference				
Manurial I					
No manure	Nil	57.3	71	13.6	6
Composted manure	1	59.7	75	26.3	20
„ „	2	59.0	74	38.7	39
Least significant difference					
p = 0.05	—	2.1	—	11.7	—
p = 0.01	—	—	—	15.7	—
Manurial II					
No manure	Nil	17.1	9	29.0	23
Composted manure	4	34.3	32	47.1	54
Least significant difference					
p = 0.05	—	13.2	—	11.7	—
p = 0.01	—	—	—	15.7	—

Notes: * Degrees after angular transformation for statistical analysis.

† Percentage of the fungal growth in the soil test treatment receiving all nutrients.

NS Not significant.

MANURIAL, FERTILIZER AND MULCH TRIALS

MANURIAL TRIAL I

Since 1957 an important object of this trial has been to compare the efficiency of urea and ammonium sulphate as sources of nitrogen for the coffee plant. The results of this comparison are now available from three seasons, but a clear-cut answer is not revealed. So far urea has been the less effective and in fact has failed to raise significantly the mean annual yield of coffee for the period 1957-1959.

TABLE XII

Yield Summary 1951-1959

(Cwt. clean coffee per acre per annum)

		Composted Cattle Manure			*Means for Nitrogen treatments*
		C_0 *Nil*	C_1 *1 4-gall. tin/tree*	C_2 *2 4-gall. tin/tree*	
(a)	*1959*				
	Nitrogen				
	No Nil	3.54	3.69	4.34	3.86
	N1 46 lb. per acre as urea	4.09	4.75	5.47	4.77
	N2 46 lb. per acre as ammonium sulphate	4.88	3.95	6.00	4.94
	Means for cattle manure treatments	4.17	4.13	5.27	4.52
	Least significant difference between marginal means p = 0.05	—	—	—	0.93
	Coefficient of variation	—	—	—	20.49%
(b)	*1957-1959*				
	No Nil	8.82	8.58	9.82	9.07
	N1 46 lb. per acre as urea	8.89	9.43	10.55	9.62
	N2 46 lb. per acre as ammonium sulphate	10.63	9.71	11.17	10.50
	Means for cattle manure treatments	9.44	9.24	10.51	9.73
	Least significant difference between marginal means p = 0.05	—	—	—	0.90
	p = 0.01	—	—	—	1.24
	Coefficient of variation				9.23%
(c)	*1951-1959*				
	No Nil	8.04	8.30	9.16	8.50
	N2 46 lb. per acre as ammonium sulphate	9.91	9.04	9.95	9.63
	Means for cattle manure treatments	8.98	8.67	9.56	9.07
				Manure treatments	*Nitrogen treatments*
	Least significant difference between marginal means p = 0.05	—	—	0.91	0.64
	p = 0.01	—	—	1.26	0.89
	p = 0.001	—	—	1.75	1.24
	Coefficient of variation 5.82%	—	—	—	

(a) The 1959 crop was carried on young heads of a new primary pruning cycle and the average yield for the trial was only four and a half cwt. of clean coffee per acre. The overall figures showed a slight but significant response to two 4-gallon tins of cattle manure. By the f test the effect of the nitrogen treatments just failed to attain the 5% level of significance.

(b) The mean annual yields for 1957-1959 show an overall response to the higher application of cattle manure and to the ammonium sulphate. It is considered that the urea has been tested under somewhat adverse conditions since 1957 and 1958 were notably wet years which would not favour this fertilizer, and during 1958 and 1959 the coffee was in the process of being converted from one pruning cycle to the next. This had the effect of temporarily lowering the yields and possibly the requirements for nitrogen. During 1958 and 1959 neither fertilizer raised the overall yields significantly and the overall advantage to ammonium sulphate shown in Table XII can be traced back to the heavy crop of 1957 when this fertilizer raised the yield of clean coffee by 3 cwt. per acre (22.15 to 25.16 cwt.)

(c) The mean yields for the nine crops, 1951-1959, show no response to cattle manure, but to the application of 46 lb. of nitrogen per acre as 2 cwt. of ammonium sulphate the mean increase in yield has been just over 1 cwt. of clean coffee per year.

TABLE XIII

Summary of soil analysis of samples collected in January 1959

Treatments	*pH*	*K* Meq. %	*Ca* Meq. %	*Mg* Meq. %	*P* ppm
No	6.2	1.8	6.6	2.9	12
N1	6.0	1.8	6.7	2.9	15
N2	5.8	1.7	6.2	2.7	11
Co	5.9	1.2	6.5	2.9	13
C1	5.8	1.7	6.1	2.8	11
C2	6.0	2.5	7.0	2.8	14
Least significant difference p=0.05	N.S.	0.1	N.S.	0.2	N.S.

The results of an extensive soil sampling carried out early in 1959 are summarised in Table XIII. The abbreviations No, NI, N2 and Co, CI, C2 refer to the treatments described in Table XII and the values are means of 18 chemical analyses of soil collected from two depths (0-8″, 8″-16″) from nine plots.

There is a suggestion that pH values are lower when nitrogen fertilizer has been applied and with ammonium sulphate (N2) the levels of exchangeable potassium and magnesium are significantly lower than the others.

The exchangeable potassium in the soil has been raised substantially by the application of cattle manure.

MANURIAL TRIAL II

Ten crops have been recorded from this trial and a survey of the results shows a great consistency in the yield responses over this period.

TABLE XIV

Yield Summary—1950-1959

(Cwt. clean coffee per acre per annum)

Treatments applied annually	*1959*	*1950-1959*
(1) Control	2.89	7.45
N. 92 lb. nitrogen/acre	7.20	9.14
P. 92 lb. citric soluble P205	2.14	6.92
N + P.	5.98	9.21
C 4 4-gall. tins cattle manure/tree	4.85	7.98
N + C	6.22	9.19
P + C	4.54	7.84
N + P + C	7.05	8.75
Mean	5.11	8.31
Least significant difference		
p = 0.05	1.66	0.65
p = 0.01	2.28	0.90
p = 0.001	3.14	1.25
Coefficient of variation	15.30%	3.69%

The responses shown in the 1959 figures are typical in form but not degree. For this season the nitrogen treatment alone raised the yield of clean coffee by over 4 cwt. per acre whereas a detailed analysis of the ten-year mean figures shows that the overall effect of the nitrogen fertilizer has been to increase the annual yield by 1.52 cwt. of clean coffee per acre. As shown below, the response to 92 lb. nitrogen per acre has been an increase of 2 cwt. a year in the absence of cattle manure.

Cattle manure has failed to increase the overall yield of coffee significantly in nine out of the ten crops recorded. The exception was 1959 when the application of four 4-gallon tins of manure per tree finally succeeded in raising the yield by 1.11 cwt. of clean coffee per acre. The overall mean annual yields for the ten-year period show no significant effect of cattle manure, but they do reveal a negative interaction between the nitrogen fertilizer and cattle manure.

TABLE XV

Nitrogen X Cattle Manure Interaction Mean Yields for 1950-1959

	Cattle Manure		
	Without C	*With C*	*Effect of C*
Nitrogen			
Without N . . .	7.18	7.91	+0.73
With N	9.18	8.97	—0.21
Effect of N	+2.00	+1.06	—
Least significant difference			
p = 0.05 . . .		0.46	
p = 0.01 . . .		0.63	
p = 0.001 . . .		0.88	

In the absence of nitrogen fertilizer there has been a mean annual response to cattle manure of about 3/4 cwt. per acre (p=0.01), but where it has been used wth the fertilizer it has failed to increase the yield at all. Moreover, the cattle manure has reduced the positive response to the nitrogen fertilizer from 2.00 to 1.06 cwt. of clean coffee per acre.

MANURIAL TRIAL III

This trial was laid down in 1952 to study the importance of the season at which nitrogen fertilizer should be applied to coffee. In order to make the best use of the coffee then available this experiment was designed as a 3 × 3 factorial with three replications so that it would fit on one replicate of the original 3×3×3 layout of Manurial Trial I. In the years 1952 to 1956 ammonium sulphate was the fertilizer used but for the last three years the nitrogen has been applied in the form of urea.

TABLE XVI

Yield Summary 1952-1959

(Cwt. clean coffee per acre per annum)

	Time of Fertilizer Application			*Means for fertilizer treatments*
	To Long Rains	*T1 Short Rains*	*T2 ½ Long Rains ½ Short Rains*	
Nitrogen Fertilizer per acre				
No Nil	7.08	7.16	7.54	7.26
N1 46 lb. nitrogen	7.97	7.67	8.25	7.96
N2 92 lb. nitrogen	8.43	8.32	8.42	8.38
Means for timing	7.83	7.72	8.07	7.87
Least significant difference				
p = 0.05	*Within the table*			*Marginal means*
p = 0.01	*No significant difference*			0.76
				1.05
Coefficient of variation				9.70%

The mean annual yields shown in Table XVI provide a complete summary of this trial which was concluded with the picking of the 1959 crop. The overall response to the fertilizer treatments has been slight and only statistically significant where the nitrogen was applied at 92 lb. per acre annually. There is no detectable difference between the time of application of the higher rate of fertilizer dressing which seems to have been equally effective whenever it has been distributed but at the 46 lb. rate the nitrogen applied early in the Short Rains appears to have been less efficient than when the same amount has been applied early in the Long Rains. These conjectures are not firmly based, since both the effect of Time and the Nitrogen+Time interaction fails to attain statistical significance.

TABLE XVII

Summary of Soil Analysis Samples Collected March, 1959

	pH			*K Meq. %*			*Ca Meq. %*			*Mg. Meq. %*			*P ppm.*		
Depth of sample	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean
Treatment															
No	6.2	6.1	6.2	1.5	1.1	1.3	8.9	6.0	7.5	3.2	2.7	3.0	9	7	8
N1	5.9	6.0	6.0	1.4	1.1	1.3	8.2	5.4	6.9	2.7	2.5	2.6	15	15	15
N2	5.7	6.1	5.9	1.3	1.2	1.3	8.7	6.5	7.6	2.6	2.4	2.5	15	15	15
To (Po)	5.9	5.7	5.8	1.3	1.0	1.2	7.9	4.5	6.2	3.0	2.4	2.6	12	11	11
T1 (P1)	6.1	6.1	6.1	1.4	1.2	1.3	8.9	6.3	7.6	2.9	2.7	2.8	14	12	13
T2 (P2)	6.0	6.3	6.1	1.4	1.2	1.3	9.1	7.1	8.1	2.7	2.6	2.7	14	13	14
Least significant difference															
p = 0.05			0.3	*No significant difference*					1.2			0.3			2
p = 0.01			—						1.6			—			—

Table XVII summarises the results of the chemical analyses of an extensive set of soil samples collected early in 1959. In the first 8″ of soil the pH values have been lowered by the nitrogen fertilizers mentioned above. With the increasing rate of fertilizer application the exchangeable magnesium values have significantly decreased, but rather surprisingly a displacement effect is not evident in the values for exchangeable potassium and calcium.

Before considering the apparent effect of the time of application of the nitrogen fertilizer on the chemical composition of the soil the previous history of these plots must be recalled. When this trial was superimposed on part of Manurial Trial I the new treatments were substituted for the old as follows:

1947-1951		1952-1956 Ammonium sulphate		1957-1959 Urea
No	0 lb. nitrogen/acre	No	0 lb. nitrogen/acre	
N1	23 lb. nitrogen/acre as ammonium sulphate	N1	46 lb. nitrogen/acre	
N2	46 lb. nitrogen/acre as ammonium sulphate	N2	92 lb. nitrogen/acre	
Po	0 lb. P_2O_5/acre	To	Nitrogen fertilizer in the Long Rains—April	
P1	45 lb. total P_2O_5 (7 lb. citric soluble) as 2 cwt./acre as soda phosphate	T1	Nitrogen fertilizer in the Short Rains—November	
P2	90 lb. total P_2O_5 (3½ lb. citric soluble) as 3½ cwt./acre, Uganda rock phosphate	T2	Half the fertilizer in each Rains.	

Between the 1951 and 1952 crops the following fertilizer dressing was applied to the whole of the area to be occupied by Manurial Trial III.

Soda phosphate	2 cwt. per acre
Uganda rock phosphate	3 cwt. per acre
Ammonium sulphate	2 cwt. per acre

It is probable that the unusual increase in chemical phosphorus values where nitrogen fertilizer has been applied is attributable to the effect of lowering soil pH on the residues of the soda and Uganda rock phosphates.

The application of nitrogen fertilizer as a single dressing in the Long Rains appears to have produced the greatest changes in the soil. The pH value is the lowest and both exchangeable calcium and phosphorus values seem to have been reduced significantly by this treatment. But as has been mentioned above a reduction in soil pH might be expected to release more exchangeable phosphorus from the residues of the overall fertilizer application of 1952. It is more likely that this apparent To effect is a reflection of the previous Po treatment of the 1947-1951 period to which no phosphate was applied. It is suggested that the effects shown in Table XVII can be explained by the interaction of differential nitrogen treatments (1947-1959) as they have affected the soil pH and the phosphorus treatments (1947-1951) as they influenced the phosphorus and calcium levels.

MANURIAL TRIAL IV

An important object of this trial is the study of nitrogen fertilizer placement in relation to the position of mulch in coffee. The experiment, which commenced in 1954, has now yielded six crops.

The 1959 average yield was 4.97 cwt. of clean coffee per acre and as no significant difference could be established between the treatments the results are not given here.

A detailed analysis of the mean yields for the six seasons 1954-1959 has revealed a number of interesting results. In previous reports yields from this trial have been tabulated in full and since its design is unbalanced because dummy treatments have been omitted, separate t tests have to be applied to no less than 16 combinations of treatments. This tends to confuse the reader without adding to his enlightenment so for the mean annual yields for 1954-1959 only the effects of statistical significance are shown in the following tables.

TABLE XVIII

Overall Yield Responses to Main Treatments 1954-1959

(Mean annual yields in cwt. clean coffee per acre)

	Yield	*Response*	*Significant at probability of*
Mo No mulch	9.16	—	
M1 6 ft. mulch between alternate rows	10.14	+0.98	p=0.05
M2 4½ ft. mulch in each row	11.03	+1.87	p=0.001
M3 6 ft. mulch between all rows	10.37	+1.21	p=0.01
No No nitrogen	9.42	—	
N1 69 lb. nitrogen per acre	10.46	+1.04	p=0.01
N2 138 lb. nitrogen per acre	10.61	+1.19	p=0.01

The overall response to mulch was an increase in yield of 0.98 cwt. per year with alternate inter-row mulch and when the average width of mulch per tree was raised from 3 to 4½ ft. applied along each row the response practically doubled to an increase of 1.87 cwt per year. A further increase in mulch width to 6 ft. per tree failed to improve the response. Both rates of nitrogen fertilizer raised the yield of coffee by about 1 cwt. per year, and the lower rate was as effective in this as the higher.

TABLE XIX

The Influence of Fertilizer Placement on the Response to Nitrogen

(Mean annual yields for 1954-1959 in cwt. clean coffee per acre)

(Mulched plots only)

Treatments applied annually lb. nitrogen per acre	*Fertilizer Placement*		*Means for fertilizer rates*
No Nil	9.72		
	To bare soil	*Over the mulch*	
N1 69	11.25	10.30	10.78
N2 138	10.93	10.57	10.75
Means for fertilizer placement	11.09	10.44	10.77
Least significant difference	*Within the Table*	*Between Marginal Means*	
p=0.05	0.91	0.65	
p=0.01	1.23	0.87	

Fertilizer placement is shown to be very important in Table XIX for where it has been scattered over the mulch the nitrogen fertilizer has failed to raise the yield of coffee significantly. On the other hand significant responses are shown at both rates where the fertilizer has been distributed over the bare soil.

TABLE XX

The Response to Nitrogen Applied to Bare Soil Beside a 4½ ft. Inrow Mulch (M2)

(Mean annual yields for 1954-1959 in cwt. clean coffee per acre)

Treatments applied annually	*Mulch treatment*		*Means for fertilizer*
	Nil	*In row*	
lb. Nitrogen per acre			
No Nil	8.50	9.88	9.19
N1 69	9.20	11.14	10.17
N2 138	9.79	12.31	11.05
Means for mulch	9.16	11.11	10.14
Least significant difference	*Within the table*	*Fertilizer means*	*Mulch means*
p=0.05	1.58	1.12	0.91
p=0.01	2.12	1.50	1.23
p=0.001	2.80	1.98	1.62

The most satisfactory combination of treatments in this trial is that in which the nitrogen fertilizer has been applied to the bare soil on either side of a band of mulch 4½ ft. wide laid along each row of coffee trees. As shown in Table XX no sign of a negative interaction between nitrogen and mulch is evident and indeed there is a suggestion that a positive interaction may be detected when more data has been gathered.

MANURIAL TRIAL V

The principal object of this trial is to study the effect of grass mulch on the magnesium and calcium nutrition of the coffee tree. Nitrogen fertilizer treatments are included to ensure that the yields shall not be limited by a shortage of this element.

The experiment was laid out in November 1957 in coffee which had been planted 18 months previously. The magnesium treatments are 0, ¼, ½ and 1 lb. of Kieserite per tree applied before the Long Rains. The nitrogen treatments are 0, 46 and 92 lb. nitrogen per acre applied during the Long Rains, and mulch is applied to half the plots in alternate inter-rows. Each plot is split for the presence or absence of hydrated lime at 1 cwt. per acre annually. The first crop was borne in 1959 when only the mulching raised significantly the yield of clean coffee.

TABLE XXI

1959 YIELDS

The Interaction of Magnesium and Mulch

(cwt. clean coffee per acre)

Magnesium fertilizer per tree	*No mulch*	*Alternate inter-row mulch*	*Means for Fertilizer*
Nil	8.40	9.85	9.12
¼ lb. Kieserite	6.39	9.97	8.18
½ lb. Kieserite	7.20	9.57	8.39
1 lb. Kieserite	6.80	9.19	8.00
Means for Mulch	7.20	9.64	8.42
Least significant difference	*Within the table*	*Between fertilizer means*	*Between mulch means*
p=0.05	3.08	2.18	1.54
p=0.01	4.56	3.22	2.28

The nitrogen, magnesium and calcium treatments all failed to increase yields and, where it was used without mulch, there is an indication that the magnesium fertilizer may have depressed the yield, though this interaction is far from statistical significance. A visual score of leaf symptoms of magnesium deficiency made in May 1959 showed that the Kieserite was effective in reducing substantially the incidence of deficient leaves. This was in accordance with the results of the chemical analysis of soil samples collected from this trial at the end of 1958.

TABLE XXII

SOIL SAMPLES—DECEMBER 1958

Summary of the Chemical Analysis of the Top 8" of Soil

Main Treatments + Calcium	*pH*	*K Meq. %*	*Ca Meq. %*	*Mg. Meq. %*	*P ppm*
Magnesium					
Nil	5.9	2.0	6.3	2.2	17
¼ lb. Kieserite/tree	5.7	1.6	5.2	2.7	15
½ lb. „ „	6.0	1.7	6.8	2.5	16
1 lb. „ „	5.8	2.0	6.2	2.7	14
Least significant difference p=0.001	N.S.	N.S.	N.S.	0.2	N.S.
Nitrogen					
Nil	5.9	1.9	6.1	2.5	15
46 lb. per acre	5.8	1.8	5.9	2.5	15
92 lb. per acre	5.8	1.7	6.3	2.5	17
	No significant difference				
Mulch					
Nil	5.8	1.3	6.0	2.4	13
Alternate inter-row	5.9	2.3	6.2	2.6	18
Least significant difference					
p=0.01	N.S.	0.8	N.S.	—	N.S.
p=0.001	—	—	—	0.1	—
Sub-treatment					
Calcium Nil	5.8	1.8	6.1	2.6	16
1 cwt. hydrated lime/acre	5.9	1.8	6.1	2.4	15
	No significant difference				

The magnesium fertilizer treatments have raised the exchangeable magnesium level in the soil significantly but no other significant effects were found.

The nitrogen fertilizer treatments, in the form of urea, have produced no differential effects in the chemical soil data.

The presence of a Napier grass mulch has significantly increased the exchangeable soil potassium and has raised the exchangeable magnesium also.

The split plot calcium hydroxide treatment has not influenced the soil analysis values significantly to date.

TABLE XXIII

SOIL SAMPLES DECEMBER 1958

Summary of the Biological Analysis of the Top 8" of Soil

Main Treatments + Calcium	*Nitrogen*		*Phosphorus*		*Sulphur*	
	*Degree**	%†	*Degree*	%	*Degree*	%
Magnesium						
Nil	25.3	18	38.5	39	68.0	86
¼ lb. Kieserite/tree	19.9	11	24.6	17	55.7	68
½ lb. „ „	26.4	20	36.7	36	72.5	91
1 lb. „ „	27.5	21	35.3	33	71.5	90
	No significant difference					
Nitrogen						
Nil	21.8	14	34.4	32	65.0	82
46 lb./acre	21.9	14	34.2	32	68.1	86
92 lb./acre	30.6	26	33.1	30	67.6	85
	No significant difference					
Mulch						
Nil	21.5	13	27.2	21	65.6	83
Alternate inter-row	28.1	22	40.8	42	68.2	86
Least significant difference p=0.01	N.S.		16.6		N.S.	
Sub-treatment Calcium						
Nil	26.8	20	28.6	23	68.9	87
1 cwt. hydrated lime/acre	22.7	15	39.3	40	64.9	82
Least significant difference p=0.05	N.S.		8.6		N.S.	

Notes: * Degrees after angular transformation for statistical analysis.

† Percentage of the fungal growth in the soil test treatment receiving all nutrients.

N.S. Not significant.

Neither the magnesium nor the nitrogen fertilizer treatments have resulted in significant effects being found in the biological analyses values for nitrogen, phosphorus or sulphur. However, both the mulch and the calcium hydroxide treatments have increased the biological values found for phosphorus.

Two interesting interactions between nitrogen fertilizer and Napier grass mulch are shown in the nitrogen and phosphorus results. Too much importance should not be attached to these interactions, which are demonstrated inTable XXIV.

TABLE XXIV

Interaction of Nitrogen x Mulch Treatments on Biological Analysis Results for Nitrogen and Phosphorus

Nitrogen fertilizer treatment	*Analysis*	*No Mulch*		*Alternate inter-row mulch*	
		*Degree**	%†	*Degree*	%
Nil	N.	33.6	31	10.0	3
	P.	30.3	25	38.4	39
46 lb./acre	N.	13.1	5	30.7	26
	P.	35.2	33	33.5	31
92 lb./acre	N.	17.9	9	43.4	47
	P.	16.1	8	50.2	59
Least significant difference p=0.05	N.	21.7 degrees			
	P.	15.7 „			

Notes: * Degrees after angular transformation for statistical analysis.
† Percentage of the fungal growth in the soil test treatment receiving all nutrients.

In the absence of nitrogen fertilizer mulch considerably depressed the quantity of nitrogen available to the test fungus. At the 46 lb. nitrogen application per acre the fungal growth on the mulched soil was about the same as on the soil which had not been mulched or fertilized, and was intermediate between the mulch alone and the mulch with the addition of 92 lb. nitrogen per acre.

The influence of mulch and nitrogen fertilizer on the biological phosphorus values is very marked but difficult to interpret logically. Apparently the presence of mulch, and the phosphorus derived from its decomposition, has resulted in the soil phosphorus level and availability being maintained and even increased in the presence of the 96 lb. nitrogen per acre.

MANURIAL TRIAL VI

In this trial the 1959 yields were very low, highly variable and revealed no significant difference between treatments. When combined with the very high yields of the previous season the coefficient of variation comes down to 15.64%, but still there is no significant effect of either magnesium fertilizer on the yield of coffee.

TABLE XXV

Yield Summary 1958-1959

(cwt. clean coffee per acre per annum)

lb. Fertilizer per acre		*Kieserite*			*Means for Magnesite*
		0	*112*	*224*	
	lb. Mg. per acre	*0*	*18*	*36*	
Magnesite					
0	0	10.22	11.56	10.98	10.92
70	18	9.56	9.72	9.87	9.71
140	36	11.96	11.61	11.21	11.59
Means for Kieserite		10.58	10.96	10.68	10.74
		No significant difference			

There is a suggestion that 70 lb. per acre of magnesite is inferior to 140 lb. and also worse than nothing at all. No attempt will be made to explain this trend at present.

TABLE XXVI

Summary of the Soil Analysis of Samples collected in November, 1958

TREATMENTS Annual applications in lb./acre	Sample depth	*pH*			*K Meq. %*			*Ca Meq. %*			*Mg. Meq. %*			*P ppm.*		
		0–8″	8″–16″	Mean	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean
Kieserite	*Magnesite*															
0	0	5.5	5.7	5.6	1.9	1.3	1.6	5.6	4.4	5.0	2.9	2.5	2.7	17	16	16
0	70	5.5	5.3	5.4	2.1	1.2	1.7	4.8	3.4	4.1	2.8	2.4	2.6	14	10	12
0	140	5.7	5.8	5.7	1.9	1.4	1.7	6.0	4.8	5.4	2.7	2.8	2.8	15	13	14
112	0	5.6	5.4	5.5	1.8	1.1	1.5	5.4	3.8	4.6	3.8	2.3	3.1	3	10	12
112	70	5.4	5.3	5.3	1.9	1.1	1.6	4.6	3.0	3.8	2.4	2.1	2.3	14	12	13
112	140	5.0	5.4	5.2	1.5	1.3	1.4	4.3	3.7	4.0	2.4	2.3	2.4	13	12	13
224	0	5.3	5.3	5.3	1.6	1.2	1.4	3.6	3.2	3.4	2.7	2.6	2.7	15	12	13
224	70	5.7	5.8	5.7	2.2	1.1	1.7	5.4	3.9	4.7	2.6	2.5	2.6	13	11	12
224	140	5.3	5.3	5.3	1.7	0.9	1.3	4.6	3.3	4.0	2.6	2.3	2.5	11	11	11
Least significant difference p = 0.05				0.3			N.S.			1.2			N.S.			N.S.
Coefficient of variation				7%			38%			34%			18%			36%
Under Mulch		5.4	5.5	5.5	1.4	1.1	1.3	5.2	3.6	4.4	2.8	2.4	2.6	13	12	12
Between Mulch strips		5.6	5.5	5.5	2.2	1.2	1.7	4.7	3.8	4.2	2.5	2.4	2.5	15	12	13
Least significant difference p = 0.001				N.S.			0.3			N.S.			N.S.			N.S.

An extensive series of soil samples was collected from this experiment in November 1958 one year after it had been commenced. The results of the chemical analysis of this material are given in Table XXVI. The analyses illustrate the variability of the trial area but apart from the influence of the mulch on the exchangeable soil potassium it is difficult to explain any of the significant effects obtained in relation to the magnesium fertilizer treatments. Further investigation may explain the significance of the variations between treatments of soil pH and exchangeable calcium. Indeed, the main value of this series of soil analyses may well be for comparison wih the results of future sampling.

MANURIAL TRIAL VII

This experiment was commenced in 1957 as a preliminary investigation into the efficiency of foliar sprays as a means of raising coffee yields. The application to the ground of 50, 100 and 200 lb. urea has been compared with 25, 50 and 100 lb. urea per acre in a 2.5% w/w solution and the same amounts in a constant volume of spray per acre of 20 gallons. The high volume sprays have been put on with stirrup pumps and the low volume treatments applied with a Micron Meg in 1957 and a Motoblo in 1958 and 1959. The mean annual yields for these three years are given in Table XXVII.

At both the 100 and 200 lb. rates of urea applied to the ground yields have been significantly raised by about 2 cwt. of clean coffee per year and 100 lb. urea in 20 gallons has also succeeded in similarly improving the coffee production. None of the other treatments affected yields significantly. The overall mean figures show that while the ground and low volume applications or urea were effective, the high volume sprays failed to increase the yield sufficiently to attain statistical significance. There is a trend in the mean yields for the nitrogen fertilizer treatments showing increasing production with increasing urea application, but only the 100 and 200 lb. rates of urea have significantly increased the yield of clean coffee.

TABLE XXVII

Yield Summary 1957-1959

(cwt. clean coffee per acre per annum)

lb. Urea per acre	*lb. Nitrogen per acre*	*Method of Application*				*Means*	*Percent response*
		Nil	*Dry to ground*	*Foliar Spray*			
				High vol.	*Low vol.*		
0	0	a.7.29	—	—	—	a.7.29	—
25	11½	—	—	a.8.52	a.8.26	b.8.39	+15%
50	23	—	a.8.31	a.8.67	a.9.01	c.8.66	+19%
100	46	—	a.9.61	a.8.19	a.9.56	c.9.12	+25%
200	92	—	a.9.29	—	—	a.9.29	+27%
		a.7.29	c.9.07	c.8.46	c.8.94	—	—

Least significant difference p=0.05	a and a.	a. and b.	a. and c.	c. and c.	b. and c.
	1.87	1.62	1.53	1.08	1.21

Coefficient of variation 12.74%

In April 1958 the first fully open, though immature, leaf pairs were sampled but in April 1959 4th leaf pair samples were collected. This change was made because the 1958 samples showed large variations between replicates and between successive samples; mature leaf samples, it was thought, would overcome this problem to some degree.

TABLE XXVIII

The Absorption of Nitrogen from Urea by Coffee Leaves

(Percentage nitrogen in leaf dry matter)

Time of sampling	*No urea spray*		*Low Volume urea spray (50 lb./20 gals.)*	
	1958	*1959*	*1958*	*1959*
Before spraying . . .	2.31	1.94	2.04	1.95
1 hour after . . .	2.10	2.03	2.32	2.19
2 ,, ,, . . .	2.12	1.94	2.32	1.97
4 ,, ,, . . .	2.00	2.06	2.32	1.97
8 ,, ,, . . .	—	2.00	—	2.04
24 ,, ,, . . .	2.10	2.04	2.42	2.09
48 ,, ,, . . .	2.10	2.07	2.46	2.06
72 ,, ,, . . .	—	2.12	—	2.03
Least significant difference				
p=0.05 . . .	0.19	N.S.	0.19	N.S.
0=0.01 . . .	0.26	—	0.26	—

Substantial differences in nitrogen content between urea sprayed and unsprayed leaves were found in the 1958 samples; mature leaf samples collected in 1959 after exactly the same treatment and times do not show any differences. It is concluded tentatively that absorption through the surface of mature foliage is either small and/or very slow and that this is why no appreciable differences in leaf nitrogen values were detected.

MULCH TRIAL

The new pruning cycle came into full bearing on this trial in 1959, and the average yield for the trial was just under three quarters of a ton of clean coffee per acre.

The mulch treatments applied before the onset of the Long Rains increased the yield of clean coffee by as much as 4 cwt. per acre while the July treatment raised the yield by about $2\frac{1}{2}$ cwt. per acre.

TABLE XXIX

Yield Summary 1959 cwt. clean coffee per acre

	No Nitrogen	*Urea 46 lb. Nitrogen/ Acre*	*Sodium Nitrate 46 lb. Nitrogen/ Acre*	*Ammonium Sulphate Nitrate 46 lb. Nitrogen/ Acre*	*Means for Mulch treatments*
No mulch	11.58	12.85	13.14	11.69	12.31
All inter-rows Pre-Rains—March	15.60	16.74	16.39	17.48	16.55
Alternate inter-rows pre-Rains—March	15.68	14.61	15.84	15.15	15.32
All inter-rows Post-Rains—July	14.05	14.59	16.25	14.20	14.77
Means for fertilizer treatments	14.23	14.70	15.40	14.63	14.74

Least Significant Difference	*Within the table*	*Between marginal means*
p=0.05	1.88	0.94
p=0.01	2.54	1.27
Coefficient of variation	8.84%	

In 1959 the treatment which consisted since 1954 of applying 46 lb. of nitrogen per acre half in the ammonium and half in the nitrate form was modified by using as the fertilizer ammonium sulphate nitrate (A.S.N.) to supply the same rate of nitrogen per acre. Although the overall response to this treatment was not significant, where A.S.N. was put on to the bare soil in April between an all-inter-row mulch, which had been laid in March, there was an increase in yield which just attained statistical significance. As shown by the mean yields at the bottom of Table XXIX, there was a significant overall response to the sodium nitrate fertilizer. In this case the main yield increases were recorded from unmulched plots or those which were not mulched until three months after the fertilizer had been applied.

TABLE XXX

The Effect of Mulch on Bean Size 1951-1958

(Mean annual yields of coffee in cwt. clean coffee per acre)

Grade A Screen = 6.75 mm.

	Yield of Grade A Coffee	*Yield Increases*	*Yield of less than Grade A*	*Total Yield*	*Yield Increase %*
No mulch	2.52	—	4.08	6.60	—
All inter-rows pre-Rains—March	4.34	+72%	5.26	9.60	+45%
Alternate inter-rows pre-Rains—March	3.34	+33%	5.41	8.75	+33%
All inter-rows post-Rains—July	4.58	+82%	5.76	10.34	+57%
Least Significant Difference					
p=0.05	0.91	36%		1.71	26%
p=0 01	1.23	49%		2.30	35%
p=0.001	1.63	65%		3.06	46%
Coefficient of Variation	11.41%			8.80%	

At each picking for each season since 1951 1/10th samples have been taken from the yield of each plot of the trial. At the end of each picking season the aggregate samples which are formed by bulking all the samples for each plot, have been hulled and graded. From this procedure it has been possible to obtain the information shown in Table XXX, which shows the effect that the various mulch treatments have had on the yield of Grade 'A' coffee. The mulch placed between alternate rows in March each year has increased the general mean yield for the eight years by 33% and the quantity of Grade 'A' coffee has risen by the same proportion. Where the mulch has been laid between all rows of coffee in March or July, not only has the mean overall annual yield been increased by between 45% and 57% but furthermore the proportion of Grade 'A' coffee has risen to a greater extent so that these treatments have produced between 72% and 82% more large sized beans than have been picked from the unmulched plots.

On many occasions samples of coffee from the various treatments in this trial have been submitted to the Liquorer of the Coffee Marketing Board of Kenya. From his detailed reports on the appearance of the coffee raw or roasted and his comments on the coffee liquors no consistent effects of cultural treatments on the final classification of the coffee have been detectable.

From this work on coffee quality it is concluded that all three mulching treatments have raised substantially the yields of all sizes of coffee bean and that the all inter-row mulch treatments have increased the proportion of Grade 'A' coffee. There is no evidence that these increases in yield have been associated with any reduction in quality as represented by descriptions of raw or roasted coffee or by reports on the coffee liquor.

One of the principal objects of this trial has been to test the possibility of regenerating the soil structure while continuing to crop the original coffee. The combination of mulching with cattle manure and nitrogen fertilizers was designed to build soil structure and to raise the general level of plant nutrients. The experiment, which commenced in 1949, was laid down in a block of debilitated coffee situated on a slope which had been seriously eroded. The residual dark topsoil ranged in depth from 8 to 0 inches.

The effects of the various treatments on soil structure have already been reported (Pereira and Jones, 1954), and now results are available for the chemical analysis of soil samples taken early in 1959.

TABLE XXXI

Summary of Soil Analysis Data from the Mulch Trial, February 1959

	pH			*Na. Meq. %*			*K. Meq. %*			*Ca. Meq. %*			*Mg. Meq. %*			*P. ppm*		
Depth of soil sample	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean	0–8″	8″–16″	Mean
Treatments applied annually																		
Control	5.7	5.6	5.7	0.1	0.1	0.1	1.5	1.0	1.3	5.5	2.6	4.1	3.2	3.2	3.2	25	17	21
†Urea—46 lb. Nitrogen per acre	5.9	6.4	6.2	0.1	0.1	0.1	1.5	1.4	1.5	7.2	5.0	6.1	4.3	4.5	4.4	20	15	18
Sodium—46 lb. Nitrate Nitrogen per acre	5.9	5.6	5.8	0.5	0.6	0.4	1.3	1.7	1.5	5.5	3.1	4.3	3.3	2.6	3.0	17	11	14
†Urea—23 lb. Nitrogen+ Sodium Nitrate—23 lb. Nitrogen per acre	5.6	5.6	5.6	0.2	0.2	0.2	1.2	1.1	1.1	4.2	3.0	3.6	2.5	3.0	2.8	12	17	15
Cattle Manure*	6.3	6.0	6.2	0.1	0.1	0.1	2.6	1.5	2.1	6.2	2.3	4.3	3.7	2.8	3.3	16	11	14
All inter-row mulch in March	5.6	5.1	5.4	0.1	0.1	0.1	2.5	2.1	2.3	5.0	2.5	3.8	3.1	2.7	2.5	17	14	15
All inter-row mulch in July	6.3	5.7	6.0	0.1	0.1	0.1	1.8	2.7	2.3	4.9	2.0	3.5	2.6	1.8	2.9	16	11	13
All inter-row mulch+cattle manure*	6.5	6.0	6.3	0.1	0.1	0.1	3.1	2.5	2.8	5.4	2.5	4.0	3.3	1.7	2.5	44	19	31
Coefficient of variation			6%			56%			34%			53%			30%			62%
Least significant difference																		
p = 0.05			0.3			0.1			0.6			—			1.0			11
p = 0.01			0.5			—			0.8			—			1.3			—
p = 0.001			0.6			0.2			1.1			—			2.0			—

**Last application of cattle manure in March 1957. †Treatment modified to ammonium sulphate nitrate after sampling*

The irregular depth of topsoil with which this trial started has resulted in a wide variation in the chemical fertility between plots so that the coefficients of variation shown at the foot of Table XXXI are particularly high. Despite a high degree of replication in the soil sampling this inherent variation has masked all but the most substantial treatment effects. For example, mulching with cattle manure has raised the topsoil phosphorus considerably yet the effect of either alone is not revealed in larger mean values of phosphorus, although it is known from other trials that either mulch or cattle manure can increase the amount of phosphorus in the topsoil.

Other results of interest in Table XXXI are the increase in exchangeable soil potassium following the use of mulch and cattle manure and the increase in soil sodium where sodium nitrate has been applied.

Dry Napier or Elephant Grass (*Pennisetum purpureum*) has been used as the mulching material throughout the course of this trial. This grass is known to be a luxury consumer of potassium and as much as 6% of the dry matter may be of this element. In August 1956 a visual score of magnesium deficiency symptoms of the coffee leaves revealed that its incidence was correlated with the use of mulch. This was considered to be the result of the excess potassium in the soil resulting from the decomposition of the grass mulch. Thus the ratio between soil potassium and soil magnesium had been artificially altered so that the porportion of magnesium was much reduced (Robinson and Chenery, 1958).

In 1957 the plots in the first replication of this trial were split to allow the effect of magnesium fertilizer to be tested. Since that time the magnesium treatment has been as follows:

1957 1 cwt. Kieserite per acre.
1958 2 cwt. Calmag per acre.
(soil samples taken)
1959 1 cwt. Calmag per acre.

TABLE XXXII

The Effect of Magnesium Fertilizer on the Response to Mulch, 1957-1959

(Mean annual yields in cwt. of clean coffee per acre)

	Without Magnesium	*With Magnesium*	*Effect*
No Mulch . . .	7.76	7.88	+0.12
All inter-rows pre-Rains —March . . .	11.01	11.98	+0.97
Alternate inter-rows pre-Rains —March . .	8.75	9.18	+0.43
All inter-rows post-Rains —July	12.74	11.43	—1.31
Means	10.07	10.12	+0.05

There has been no detectable effect of magnesium fertilizer on coffee yield but, as can be seen in Table XXXIII the fertilizer has had the desired effect of correcting the potassium: magnesium ratio.

The variation between the mean values for the exchangeable magnesium for the top 16″ of soil are difficult to explain, but the effect of the magnesium fertilizer applications on the exchangeable sodium and potassium are clear cut. The exchangeable sodium, derived from the sodium nitrate fertilizer, has been substantially reduced in the topsoil. This is presumably the result of displacement.

TABLE XXXIII

The Effect of Magnesium Fertilizer on the Status of Exchangeable Sodium, February 1957

Plots receiving Sodium Nitrate	*Na. meq. %*	
	0—8″	8″—16″
No Magnesium fertilizer .	0.70	0.40
With Magnesium fertilizer	0.30	0.35
Least significant difference		
p = 0.05 .	0.1	
p = 0.001 .	0.2	

Exchangeable potassium has similarly been substantially reduced in the top 16″ of soil in all the mulch treatments to which magnesium has been applied.

TABLE XXXIV

The Effect of Magnesium Fertilizer on the Status of Exchangeable Potassium, February 1959

Depth of soil sample	*Exchangeable Potassium Meq. %*				*K: Mg. Ratio*	
	—*Mg.*		+*Mg.*		—*Mg.*	+*Mg.*
	0-8″	8-16″	0-8″	8-16″	0-16″	0-16″
Treatments applied annually						
Control	1.4	0.9	1.5	1.1	1:2.6	1:2.2
All inter-row mulch in March .	2.9	2.4	1.8	1.0	1:1.0	1:1.5
All inter-row mulch in July .	1.4	3.5	0.8	2.0	1:0.8	1:2.2
All inter-rows mulch + cattle manure	3.6	3.3	2.1	1.5	1:0.7	1:1.7

This effect is most important because the magnesium fertilizer has reduced the exchangeable potassium content on mulched plots to almost the same value as recorded for the unmulched soil so that the ratio of potassium: magnesium approaches 1 : 2 rather than 1 : 1.

References

Robinson, J. B. D., and Chenery, E. M., *Emp. J. exp. Agric.;* **28,** *259.*
Pereira, H. C., and Jones, P. A., *Emp. J. exp. Agric.;* **22,** *23.*

KITALE MULCH AND FERTILIZER TRIAL

In none of the three years this trial has been recorded nor yet in the mean yields for the period can any effect of the treatments be detected in the production of coffee.

TABLE XXXV

Yield Summary 1957-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6 : 1)

Treatments	1956-1958	1959	*Yields*
A Control			7.21
B Urea lb. per acre	April 168	May 100	
		May 100	7.04
C Napier grass mulch	October		7.20
D Napier grass mulch	October		
Urea lb. per acre	April 168	May 100	
		Aug. 100	7.05
E Maize stover mulch	January		7.03
			No significant difference
Coefficient of Variation			10.12%

In 1959 the rate of nitrogen fertilizer was increased from 168 to 200 lb. of urea per acre and it was applied in two equal amounts in the months of May and August. In the previous years the fertilizer was distributed in April. It is hoped that this alteration in fertilizer timing may produce responses in terms of coffee yield. The complete lack of any response to any of the mulch treatments is remarkable and at variance with experience in other parts of Kenya. Further evidence is necessary before concluding that mulch is unnecessary for coffee growing in the vicinity of Kitale.

PRUNING TRIALS

Trial I

The yields for this trial have been recorded for 14 years, and taking the crop from groups of years or over the whole period no difference in total yield can be shown from trees pruned on the single or multiple-stem systems. In 1959 there was a far greater crop on the multiple-stem trees than on the single stem, but this is but one year in many and does not affect the overall result for the course of the experiment.

TABLE XXXVI

Yield Summary 1946-1959

(Cwt. clean coffee per acre per annum)

Pruning System	*1959*	*1946-1959*
Multiple-stem; 3 heads	13.44	7.64
Single stem; capped once	9.64	8.06
Single stem: capped thrice	8.86	7.68
Single stem; 2 stems	8.71	8.08
Mean	10.16	7.87
Least significant difference		
p=0 05	1.92	0.66
p=0 01	2.66	
p=0 001	3.67	
Coefficient of Variation	15.38%	6.84%

In previous reports it has been shown that the quality of coffee from multiple stem trees is frequently better than that from single stem coffee. It has been stated that multiple stem pruning is recommended for mature coffee plants, but for the early management of young coffee and the detailed conduct of multiple-stem pruning little precise information is available. Therefore, the following trial was designed and commenced in 1957 on young coffee planted in the previous year.

Trial II

This trial was laid down to investigate methods of controlling the amount of bearing wood per tree in order to obtain the highest yields consistent with high quality and regular bearing. Three methods of crop control are available.

(a) The removal by hand (or possibly in future by chemicals) of crop which appears to be in excess of the tree's ability to carry to ripe harvest.
(b) The reduction of primaries.
(c) The reduction of secondaries.

The design of this trial permits the study of these methods in a detailed and factorial manner.

(a) The first approach has been studied by removing crop from the trees in the (+D) plots from planting (May 1956) until October 1958. No decropping was done on the (—D) plots so that they carried a crop which was first picked June-September 1958.
(b) The control of primaries has been achieved in two ways:—

(H1) One stem has been left per tree with the intention of allowing the young trees to develop a sturdy root system, unharmed by the leverage which has been observed with the two tall heads in a multiple-stem tree. In order to keep the (HI) trees short and sturdy they were capped in October 1958 at 4′6″. Note the original seedlings had been capped in the nursery shortly before planting and were grown as multiple-stem plants until the trial was laid down in January 1957.

Further primary reduction was effected on the (HI) trees in December 1958 when the following four treatments were applied:

Lo Primaries reduced to 15 within the 4′6″ stem.
LI „ „ 20 „ „ „
L2 „ „ 25 „ „ „
L3 No reduction of primaries. Approximately 30 primaries per tree.

By December 1959 one sucker had been allowed to grow from the top of each single stem tree and in most cases had raised the total height of each tree to about six feet.

In December 1959 the number of primaries per treatment was increased as follows:

Lo 20
Ll 25 } Within 5′6″ of the ground.
L2 30
L3 Unlimited—approximately 35.

At this time the trees were not capped at 5′6″ but primaries above this level were not counted since they were immature and not expected to bear during 1960.

(H2) From the time of planting two heads were allowed per tree and these were not pruned differentially until 1959. However, in October 1958 primaries within two feet of the ground were removed except for one strong primary on each tree which was left as a breather at between 18″-24″ from the ground.

In December 1959 the following treatments were applied:

Lo Primaries cut off to two nodes above the 'break'.
Ll Primaries cut off to the 'break'.
L2 Primaries cut off to two nodes below the 'break'.
L3 Primaries cut off to four nodes below the 'break'.

Broken and interlocking primaries above these points were also thinned out at this time.

(c) The control of secondary growth:—

The intention was to permit varying amounts of crop to be borne by secondary growth on multiple-stem trees (H2) but by the nature of the factorial design of this trial these same treatments have had to be applied to single stem (H1) trees. In October 1958 and throughout the first eleven months of 1959 the following pruning treatments have been applied alike to (Hl) and (H2) trees:

So Secondaries within 18″ of main stem removed at pruning and handling.
Sl All secondaries except two terminal pairs removed at pruning and handling.
S2 All secondaries removed at pruning and those within 18″ of main stem removed at handling.
S3 All secondaries removed at all times

Extra non-factorial treatment:— February, July and October, 1959
Sx All secondaries decropped at all times

By June 1959 it was clear that as applied to the (H1) single stem trees the secondary pruning treatments under test on multiple-stem trees were unsatisfactory and would prove impossible as soon as the primaries matured sufficiently to cease bearing crop on themselves. To prevent primary die-back, and thus a loss of frame-work, overbearing trees were decropped in June 1959. By December 1959 these trees had made a reasonable recovery, but insufficient to produce much wood upon which a 1960 crop could be expected.

In order to bring the secondary reduction treatments on to a reasonable basis where applied to single stem trees it is proposed to record the S treatments as follows:

So Heavy cropping —4 units of bearing wood per primary.
Sl Medium cropping —3 „ „ „
S2 Light cropping —2 „ „ „
S3 Very light cropping —1 unit of bearing wood per primary.

In combination with the L treatments this will give the following number of bearing units per tree:—

		Lo	*L1*	*L2*	*L3*
No. of primaries on 5′6″		*20*	*25*	*30*	*35 approx.*
So Heavy cropping	—4 units	80	100	120	140
Sl Medium cropping	—3 units	60	75	90	105
S2 Light cropping	—2 units	40	50	60	70
S3 Very light cropping	—1 unit	20	25	30	35

It is proposed that a unit shall be one foot (12 inches) of bearing wood.

On the multiple-stem trees (H2) the control of secondaries will continue as originally planned.

TABLE XXXVII
1959 Yields
(Cwt. clean coffee per acre)

	H2 Multiple stem	*H1 Single stem number of primaries*				*Means for S treatments*	
		15 Lo	*20 L1*	*25 L2*	*30 L3*	*On single stem*	*Overall*
So Secondaries within 18″ of main stem removed at all times	8.86	4.83	6.05	6.96	8.83	6.66	7.76
S1 All secondaries removed at all times except two terminal pairs	10.19	4.48	7.30	8.92	7.35	7.01	8.60
S2 All secondaries removed at pruning; those within 18″ of main stem removed at all times	9.66	3.85	5.48	5.52	7.34	5.55	7.60
S3 All secondaries removed at all times	7.99	3.21	4.67	4.11	7.43	4.86	6.42
Means for L treatments	9.16	4.09	5.87	6.38	7.74	6.02	7.59
L1Sx No secondary removed: all secondaries decropped	16.77		12.00			12.00	14.38

Yields from the first year of full cropping on this experiment are summarised in Table XXXVII. Because the L. treatments were not applied to the multiple-stem trees until December 1959, the design of the trial was unbalanced in 1959 so a large number of values of "Least Significant Difference" have had to be calculated, although for simplicity they are not shown in the table. Many comparisons of statistical significance can be made, but it would be extremely rash to draw practical conclusions from one year's results. It is noticeable that in general the trends are in agreement with estate evidence already available. For instance, of the secondary pruning systems on multiple- em S1 or S2 is approximately the policy which has been adopted in Manurial Trial V—mean yield 8.42 cwt. and the General Coffee Culture Trial—mean yield 7.76 cwt. These two treatments have been superior to So or S3. On single stem the S1 system has also shown up well in the first year, and has yielded significantly more than the S2 and S3 policies. In this young single stem coffee the greater the number of primaries the more the crop in the first year, but it is interesting to see that the 25 primaries each with four secondaries L2S1 has given equally as much as 30 or more primaries each with many more secondaries L3So. The result of outstanding interest in the 1959 figures is the performance of treatment L1Sx. This was included in the trial largely as of academic interest for it was not expected that coffee growers would take the trouble to decrop all secondaries. In fact, this has not proved difficult to do and has resulted in doubling the crop on single stem trees and on multiple-stem coffee the yield has been raised by over 80%, moreover, after the final picking of 1959 the coffee trees in the L1Sx plots were noticeably more healthy than those in other plots. It is clear that this technique is worth more study if future crops support these initial results.

MACHINE SPRAY TRIAL II

Now that yields are available from the three seasons, 1957-1959, results form a fairly consistent picture showing that ten gallons of spray applied per acre can be as efficient as 60 gallons of the same concentration. The "Agro Airblast" has been used to apply the 60 gallon rate and the low volume spray has been applied with a "Micron Meg". The fungicide used has been a 50% copper wettable powder and the object of the treatments has been to prolong leaf life. Previous trials have shown that a copper spray can delay leaf fall and raise the yield of coffee in the following year. In this experiment the treatments have been applied each May from 1956 to 1959, but in addition to the experimental sprays the whole area has been treated with a copper fungicide whenever a routine treatment has been recommended as a protection against Leaf Rust. No doubt the treatments in this trial do have some effect on Leaf Rust but their timing is not ideal for this purpose, therefore the yield responses shown in Table XXXVIII should be attributed to the result of better leaf retention through means other than Rust control.

TABLE XXXVIII

Yield Summary 1957-1959.

(Cwt. clean coffee per acre per annum)

lb. 50% copper formulation per 100 galls.	*Sprayer*	*Gall. per acre*	*lb. Fungicide per acre*	*Yield cwt.*	*Response cwt.*	%
Nil	—	—	—	9.97	—	—
6.8	Agro Airblast	60	4.08	11.71	+1.74	+17
6.8	Micron Meg	10	0.68	11.30	+1.33	+13
13.6	,, ,,	10	1.36	12.93	+2.96	+30
34.0	,, ,,	10	3.40	13.18	+3.21	+32
Least significant difference	p=0 05			1.58		
	p=0 01			2.22		
	p=0.001			3.14		
Coefficient of variation				8.70%		

At 60 gallons per acre 4 lb. of a 50% copper fungicide has raised the mean annual yield of clean coffee by $1\frac{3}{4}$ cwt. per acre, but with a sixth of the liquid and a third of the copper it has been possible to raise the mean annual yield by 3 cwt. per acre using a Low Volume sprayer.

MAKUYU SPRAY TRIAL

The sole object of this experiment has been to discover the best season at which to apply a copper spray to reduce leaf fall at Makuyu.

In 1959 a startling response is shown to the treatment applied early in the Long Rains which more than doubled the yield of coffee. In previous years there has been little to choose between the treatments applied early and late in the Long Rains though they have both been superior to the Short Rains treatment. This trial has not yet had routine sprays to provide protection against Leaf Rust. It is therefore suggested that the copper sprays applied early April 1958 and posibly 1959 were effective in two ways; by controlling Leaf Rust as well as reducing premature leaf fall resulting from other causes.

TABLE XXXIX

Yield Summary 1955-1959

(Cwt. clean coffee per acre per annum)

Time of spraying		*1959*	*1955-1959*
Nil		5.66	6.44
Early Long Rains	April	14.08	9.42
Late Long Rains	June	7.11	8.39
Early Short Rains	November	7.92	7.63
Least significant difference			
p=0.05		2.07	1.06
p=0.01		2.97	1.52
p=0.001		4.36	2.23
Coefficient of variation		14.85%	8.29%

The mean yields for the five years show that at all times the copper spray has raised the crop significantly, but while the early and late Long Rains sprays have increased the annual production per acre by 3 and 2 cwt. respectively the mean response to the November spray has only been just over 1 cwt; even this represents a valuable return for a modest financial outlay.

KITALE COPPER SPRAY TRIAL

This rather complex trial was commenced in 1952 to study the effects of various times of copper spraying on the ultimate yield of coffee. Two concentrations of a copper fungicide were applied at two volumes per tree. Four times of spraying and the four combinations of spray concentration and volume are associated in a 4×4 factorial layout.

TABLE XL

Yield Summary 1953-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6:1)

Spray Composition and Volume *Pints per lb. 50% Copper Fungicide*			*Spray Timing*				*Means for spray treatments*
Tree	*per 100 galls.*	*per acre*	*No Spray*	*Mid-May*	*Mid-June*	*Late August*	
0	0	0	6.16	—	—	—	6.16
1	3.40	2.14	—	8.19	8.05	7.39	7.88
3	3.40	6.42	—	7.64	7.18	6.77	7.20
1	6.80	4.28	—	8.02	7.54	6.70	7.42
3	6.80	12.84	—	7.67	7.86	7.49	7.67
Means for Spray Timing			6.16	7.88	7.66	7.09	7.20
Least significant difference		p=0.05			0.67		
Between marginal means		p=0.01			0.91		
for Spray timing		p=0.001			1.21		
Coefficient of Variation		11.18%					

The mean annual yields for the seven seasons 1953-1959 show that by spraying with a copper fungicide in May, June or August yields of coffee can be increased by between 1 and 1½ cwt. of clean coffee per acre. The sprays applied in May have been significantly more effective than those put on in August. There is no significant difference between any of the four spray concentration and volume combinations so that the yield of coffee from trees treated with sprays of the more dilute suspension of fungicide used at the lower volume per tree has been as great as the yield from trees receiving up to six times the weight of fungicide per acre.

GENERAL COFFEE CULTURE TRIAL

This large 2^5 factorial trial was commenced in 1957 on young coffee planted in the previous year. The main object of the experiment is to provide detailed information on the ways in which various cultural treatments interact together so as to be able to advise on the most rewarding integration of good farming practices.

TABLE XLI

Yield Summary 1959

(Cwt. clean coffee per acre)

Nitrogen fertilizer	*Weeding during the Rains*		Means	*Least significant* difference	
	Weeds slashed	Clean weeding		Within the table	Between marginal means
Nil	7.06	8.47	7.76	p=0.05 1.78	1.26
100 lb. Urea per acre	8.20	7.31	7.76	p=0.01 2.39	1.69
				Coefficient of Variation	31.71%
Mulch treatments					
Nil	—	—	7.02		
Alternate inter-row	—	—	8.50		
Means for weeding	7.63	7.89	7.76		

The first crop was picked from this coffee in 1959 and although the coefficient of variation was regrettably high two interesting effects are detectable.

All alternate inter-row mulch has raised the yield by 1½ cwt. of clean coffee per acre and no other treatment has affected this result.

There is no overall response to clean weeding or the use of urea because of the negative interaction which is shown in Table XLI. In the absence of the fertilizer, clean weeding is seen to have been more satisfactory than merely slashing the weeds, however, where the weeds have been slashed there is a suggestion that urea may have raised the yield, although on the clean weeded plots the trend is in the opposite direction. Because of the somewhat high variability of the 1959 yields it is not possible to show any statistically significant differences within the table, but the negative interaction is significant at the 5% level of probability ($p=0.05$).

There was no yield response to the anti-leaf-fall copper spray applied each May and neither did this treatment modify any of the other effects described above.

The fifth treatment in this trial has not yet been allocated to any cultural measure.

EMBU MULCH AND COPPER SPRAY TRIAL

The objects of this trial are to determine the optimum degree of mulching coffee grown on bench terraces and to investigate the yield response of coffee to a single copper spray under conditions at Embu.

The experiment was commenced early in 1958 at the Embu Agricultural Investigation Centre where it is situated on coffee of the variety S.L.34 which was planted in 1955 at a spacing of 9′ × 9′.

The layout is of a 4 × 2 factorial design with four replicates and each plot consists of two rows of four trees surrounded on all sides by guard rows.

Mulching

Mo No grass mulch
M1 6 ft. band of mulch of 4″ settled depth in alternate inter-rows in alternate years.
M2 6 ft. band of mulch of 4″ settled depth in each inter-row.
M3 A total ground cover with mulch 4″ deep.

Copper Spray

So No copper
Sl 1-2 pints per tree applied in May of a suspension of 6.8 lb. of a 50% copper fungicide per 100 gallons water.

The mean yield for 1958 was 19.24 cwt. clean coffee per acre and the heavy crop imposed a serious strain upon the trees so that in 1959 the average production for the whole trial was at the rate of 6.34 cwt. per acre.

TABLE XLII

Yield Summary 1958-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean coffee ratio of 6:1)

Mulch Treatments	*No Spray*	*Copper Spray*	*Means for mulch treatments*
Mo No mulch	12.28	12.68	12.48
M1 33% ground cover	10.72	13.72	12.22
M2 66% ground cover	13.22	14.42	13.82
M3 100% ground cover	11.86	13.42	12.64
Means for Spray treatments	12.02	13.56	12.79
Least significant difference	*Within the table*	*Between mulch means*	*Between Spray Means*
p=0.05	2.86	2.02	1.43
p=0.01	3.86	2.73	1.93
Coefficient of Variation		15.29%	

The mulch treatments have so far failed to increase the yield of coffee significantly, though there is a trend suggesting that the all-inter-row mulch may prove the most satisfactory practice. The annual application of a copper spray in May has increased the mean annual yield by 1½ cwt. of clean coffee per acre and although the 1958 results showed that the response to the copper was greater in the presence of a grass mulch this is not shown in the mean yields for the two seasons together.

VARIETY TRIALS IN CENTRAL PROVINCE

COFFEE RESEARCH STATION, RUIRU. THIKA DISTRICT *Altitude:* 5,300′
Rainfall: 39″

Variety Trials I and II

Balanced incomplete block designs; 20-tree plots, planted 1950 and 1951 respectively.

In 1959 particularly heavy yields were recorded from Trial I but few differences between the varieties were of statistical significance. S.L. 28 and KIT 37 both produced over one ton of clean coffee per acre, which was significantly more than all other varieties. It is interesting to note the steady manner in which the production from KIT 37 has improved. In the mean yields for the first four crops it came 12th out of 16; after five crops 9th, after six crops 7th and in the mean yields for seven crops it stands 5th.

TABLE XLIII

VARIETY TRIAL I

Yield Summary 1953-1959

(Cwt. clean coffee per acre per annum)

Variety	*1959*	*1953-1959*
S.L.28	20.40	11.31
S.L.19	16.86	10.54
S.L.14	17.07	10.38
S.L.30	15.49	9.75
KIT 37	20.18	9.58
KIT 27	17.39	9.18
S.L.17	16.35	9.05
KIT 107	17.45	9.03
KIT 251	17.39	8.97
S.L.1	15.29	8.90
KIT 13	16.28	8.64
KIT 85	17.12	8.57
KIT 64	17.16	8.54
KIT 106	17.48	8.32
KIT 109	16.57	8.14
KIT 145	16.24	8.04
Means	17.17	9.18
Least significant difference		
p=0.05	2.39	1.15
p=0.01	3.19	1.54
Coefficient of Variation	9.77%	8.81%

TABLE XLIV

VARIETY TRIAL II

Yield Summary 1954-1959

(Cwt. clean coffee per acre per annum)

Variety	*1959*	*1954-1959*
S.L.34	7.03	10.17
N.218	4.12	10.01
Dalle (Mixed)	3.80	9.57
K.7	5.23	8.96
M.6	8.74	8.83
M.83	8.65	8.72
S.L.9	5.87	8.64
Kenya Selected	5.66	8.14
S.L.28	6.01	8.11
Mocha	8.15	8.09
Series L	5.85	8.09
N.100	9.05	8.00
M.65	7.58	8.00
Kents	6.63	7.98
K.P.532	6.97	7.49
S.L.18	5.46	7.36
S.L.2	2.94	7.18
Dilla and Alghe	5.95	7.04
S.L.10	3.91	6.94
M.48	7.09	6.88
S.L.6	3.72	6.52
Means	6.11	8.13
Least significant difference		
p=0.05	1.60	1.36
p=0.01	2.12	1.81
Coefficient of Variation	18.91%	12.12%

Trial II was planted a year later than Trial I so yields are now available from six crops. 1959 was a season of moderate crop throughout this trial, but did reveal a number of varietal differences. In particular the improved performance of selections from Morini Estate (M series) is of interest. The particularly low yield from S.L.6 is surprising as this is a selection from Kents which has a considerable resistance to Leaf Rust. The most consistently productive selections in this trial continue to be S.L.34 and the Tanganyika variety N.218.

KENTMERE. KIAMBU DISTRICT

Altitude: 6,300′
Rainfall: 48″

Trial I 4×4 Balanced lattice; 15-tree plots; planted 1954.

Trial II 3×3 Balanced lattice; 15-tree plots; planted 1954.

In 1954 two variety trials were planted on Kentmere Estate in Upper Kiambu to test a number of selections which were of interest to coffee growers at high altitudes and those in areas where Coffee Berry Disease is likely to be a problem.

TABLE XLV

KENTMERE VARIETY TRIALS

1958 AND 1959

(Yields in cwt. of clean coffee per acre.)

Variety	*1958*			*1959*		
	Rank	*Yield*	*Brown Blight Index*	*Rank*	*Yield*	*Brown Blight Index*
Trial I						
Blue Mountain						
„ K.7	2	5.90	13.84	1	4.98	5.00
„ P.12	8	4.70	15.38	2	4.88	4.38
„ S.10	10	4.28	15.00	3	4.88	2.50
„ J.7	11	4.17	14.23	4	4.79	3.75
„ N.1	9	4.41	16.15	5	4.66	5.31
„ I.11	4	5.36	13.07	6	4.23	2.81
„ Q.6	7	4.75	16.15	7	4.16	3.44
Geisha 10	16	3.58	12.30	8	4.14	13.44
Kenya Selected	13	3.95	22.30	9	4.09	5.63
Blue Mountain						
„ L.3	5	4.83	18.07	10	4.09	3.13
„ P.13	1	6.11	16.53	11	4.02	4.38
„ S.5	12	3.96	15.00	12	3.95	2.19
„ W.12	14	3.68	15.38	13	3.59	2.81
„ V.13	15	3.62	14.61	14	3.41	4.38
„ P.8	6	4.75	13.84	15	3.32	4.06
„ R.12	3	5.54	17.30	16	3.02	2.50
Mean		4.60	15.57		4.14	4.36
Coefficient of Variation		18.93%			21.05%	
Least Significant Difference p=0.05		1.11			1.11	
Trial II						
S.L.28	2	9.54	32.30	1	8.72	9.06
S.L.34	1	9.54	35.76	2	8.55	13.44
Geisha 1	8	7.93	20.76	3	8.41	11.88
Kents	3	9.27	37.30	4	5.70	17.81
Ke.20	7	8.10	24.22	5	3.51	4.06
Blue Mountain X.6	9	7.20	21.15	6	3.23	2.50
„ „ N.4	5	8.29	13.07	7	2.99	2.81
„ „ I.5	4	8.39	16.92	8	2.86	3.13
„ „ U.4	6	8.14	19.99	9	1.69	3.13
Mean	—	8.49	24.61	—	5.07	7.54
Coefficient of Variation	—	11.46	—	—	17.05	—
Least Significant Difference						
p=0 05	—	1.46	—	—	1.30	—
p=0 01	—	2.10	—	—	1.79	—
p=0.001	—	—	—	—	2.46	—

Yields recorded for the first two crops from the twenty-five selections represented in these trials are summarised in Table XLV.

In Trial I yields have been low and variations between selections slight but the results from Trial II indicate substantial varietal differences. In both years S.L.28, S.L.34 and Geisha I have yielded between 8 and 9½ cwt. of clean coffee per acre, but the crop from the Blue Mountain selections has fallen from 8 to 2¾ cwt. per acre.

The Brown Blight index represents an average percentage incidence of Brown Blight at each picking. This index shows that the 1958 intensity of attack was $3\frac{1}{2}$ times that recorded in 1959 and that Kents, S.L.34, S.L.28 and Kenya Selected are particularly susceptible; Ke.20 and Geisha I and Geisha 10 are in an intermediate group; the Blue Mountain selections are all similar in their resistance to Brown Blight.

SCOTT AGRICULTURAL LABORATORIES, KABETE, NAIROBI *Altitude:* 5,850′
Rainfall: 37″

6 Randomised Blocks; 15-tree plots; planted 1956.

TABLE XLVI

1959 yields in cwt. clean coffee per acre using as assumed Cherry: Clean Coffee ratio of 6:1.

Variety	*Yields*
S.L.28	7.26
S.L.17	5.34
S.L.18	5.30
S.L.34	5.28
Kenya Selected Series 'A'	4.96
Ke.20	3.78
S.L.6	3.50
K.7	3.21
Blue Mountain	2.81
Mean	4.60
Least Significant difference	
p=0.05	1.68
p=0.01	2.25
p=0.001	2.95
Coefficient of Variation	22.08%

In the first yields from this young coffee the superiority of S.L.28 is clearly shown. There is no significant difference between the next five selections; K.7 and S.L.6 are clearly ill suited to these conditions, but more surprising are the poor yields from Ke. 20 and Blue Mountain which are often thought to be suited to conditions of high altitude.

NORTH KITITO, MAKUYU, THIKA DISTRICT *Altitude:* 4,900′
Rainfall: 37″

Two trials were planted in Makuyu to compare the performance of six varieties of coffee at an altitude lower than the main Coffee Research Station. The same varieties were planted in both trials so as to compare the accuracy of the two layouts.

(a) The larger trial consists of five randomised blocks each with six plots of twenty trees. The spacing of the coffee is 9′ × 9′ on the square. A summary of the first four crops is given in Table XLVII.

TABLE XLVII

Yield Summary 1956-1959
(Cwt. clean coffee per acre per annum)

Variety	*1959*	*1956-1959*
S.L.28	6.90	12.12
Kents (Meru)	8.36	10.58
S.L.14	5.98	9.99
S.L.9	5.87	9.73
K.7	8.56	9.65
Kenya Selected Series 'A'	4.40	8.65
Least significant difference		
p=0.05	1.97	1.45
p=0.01	2.68	1.97
p=0.001	3.63	2.67
Coefficient of Variation	22.33%	10.84%

S.L.28 has outyielded all the other selections and Kents (Meru) is superior to Kenya Selected Series 'A', but amongst the other varieties there is no significant difference.

(b) The smaller trial consists of a 6×6 Latin Square with single trees constituting an experimental plot. Unfortunately, the coffee was planted at $8' \times 8'$ on the square so that in this respect the two trials are not comparable, though in presenting the yields per acre an allowance for this discrepancy has been made.

TABLE XLVIII

Yield Summary 1957-1959
(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6:1).

Variety		*1957-1959*
Kenya Selected Series 'A'		14.07
K.7		11.02
S.L.14		10.49
S.L.28		10.41
S.L.9		8.46
Kents (S.A.L.)		7.62
Least significant difference	p=0.05	3.12
	p=0.01	4.25
	p=0.001	5.75
Coefficient of Variation		25.03%

The results from this trial do not seem to agree with the larger experiment for here Kenya Selected Series 'A' has outyielded all others except K.7 which has produced significantly more than Kents. A closer study of the results of these two trials has shown that under Makuyu conditions Kenya Selected Series 'A' has produced very heavy yields soon after planting and thereafter its productivity has fallen off year by year. This deterioration is further advanced on the larger trial but it seems probable that in a year or so this Selection will have fallen from its leading place in the smaller trial. Amongst the other varieties both trials show that there is no important difference between their yielding capacity.

MERIGA MIERU, MERU DISTRICT

Altitude: 5,500′
Rainfall: 53″

5×5 Latin Square; 9-tree plots; planted 1951.

TABLE XLIX
Yield Summary 1954-1959
(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6:1)

Variety	*Yield*
S.L.28	19.40
S.L.34	18.82
Kenya Selected	15.96
N.100	12.01
Kents (Meru)	11.37
Mean	15.51
Least significant difference	
p=0 05	3.23
p=0 01	4.55
p=0 001	6.43
Coefficient of Variation	15.18%

In yielding nearly a ton of clean coffee per acre per annum S.L.28 has produced significantly more than all other varieties except S.L.34, whereas N.100 and Meru Kents have yielded less than the other three selections.

NKUBU, NKUENE. MERU DISTRICT

Altitude: 5,300′
Rainfall: 60″

5×5 Latin Square; single-tree plots: Planted 1951.

TABLE L
Yield Summary 1955-1959
(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6:1)

Variety	*Yield*
Series L	10.41
N.39	6.92
Kents	6 84
S.L.30	6.59
M.65	5.14
Mean	7.18
Least significant difference	
p=0 05	2.76
p=0 01	3 88
p=0.001	5 49
Coefficient of Variation	27.99%

The production of Series 'L' has been significantly greater than that of all other varieties in this trial, amongst which no difference of statistical significance can be detected.

KIRIANI, CHOGORIA. MERU DISTRICT

Altitude: 5,100′
Rainfall: 62″

5×5 Latin Square; 9-tree plots: planted 1951.

TABLE LI
Yield Summary 1955-1959
(Cwt. clean coffee per acre per annum using an assumed Cherry : Clean Coffee ratio of 6:1)

Variety	*Yield*
S.L.9	11.56
Kents (Meru)	11.33
S.L.18	11.24
S.L.28	10.34
Mocha	6.68
Mean	10.23
Least significant difference	
p=0.05	1.55
p=0.01	2.18
p=0.001	3.09
Coefficient of Variation	11.02%

Five years' results have given an accurate assessment of the five selections. A Coefficient of Variation of 11% is very satisfactory for this type of trial. Only Mocha has produced a yield significantly different from the other varieties of which S.L.28 would be suggested for local conditions on account of the good quality of the coffee it produces.

KIGUCHWA, TIGANIA. MERU DISTRICT

Altitude: 4,700′
Rainfall: 46″

5×5 Latin Square; single-tree plots; planted 1951.

TABLE LII
Yield Summary 1955-1959
(Cwt. clean coffee per acre per annum using an assumed Cherry : Clean Coffee ratio of 6:1)

Variety	*Yield*
S.L.28	11.14
S.L.9	10.54
N.100	7.39
S.L.34	6.86
Kents (Meru)	6.11
Mean	8.41
Least significant difference	
p=0 05	3.65
p=0.01	5.13
Coefficient of Variation	31.59%

The mean annual yield of the selection S.L.28 has been significantly greater than N.100, S.L.34 and Meru Kents, and S.L.9 has produced more than S.L.34 and Meru Kents. These last two varieties have done unusually poorly under conditions at Kiguchwa where the altitude is probably too low and dry for these selections although at Kajianduthi, where the rainfall is some 10 inches more a year, Meru Kents has yielded well.

KAJIANDUTHI, MUTHAMBI. MERU DISTRICT

Altitude: 4,600′
Rainfall: 56″

5×5 Latin Square; single-tree plots; planted 1951.

TABLE LIII

Yield Summary 1954-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry : Clean Coffee ratio of 6:1)

Variety	*Yield*
Kents (Meru)	14.97
S.L.18	14.16
Mocha	13.12
Series L	12.39
S.L.28	11.35
Mean	13.20
No significant difference	
Coefficient of Variation	34.66%

The high variability of this trial allows no valid comparison to be made between the yields of the five varieties, but a comparison with the results from Kiguchwa draws attention to the reversal in the relative performance of S.L.28 and Meru Kents.

KANUNI, LOWER IGEMBE. MERU DISTRICT

Altitude: 4,100′
Rainfall: 75″

7×7 Latin Square; single-tree plots; planted 1954.

TABLE LIV

Yield Summary 1958-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6:1)

Variety	*Yield*
S.L.28	11.04
S.L.14	10.91
Series L	10.42
K.7	9.14
Kenya Selected	8.15
Barbuk Forest	5.29
Columnaris	4.76
Mean	8.53
Least significant difference	
p=0.05	3.15
p=0 01	4.24
p=0 001	5.62
Coefficient of Variation	33.83%

This trial is rather less variable than the similar one at Ngeru, but the conclusions are just the same. The Barbuk Forest and Columnaris coffee has yielded considerably less than the first four selections in Table LIV, but nearly twice the crop they have produced at Ngeru under the rather lower rainfall and altitude.

NGERU, LOWER MWIMBI. MERU DISTRICT

Altitude: 4,000′
Rainfall: 65″

7×7 Latin Square; single-tree plots; planted 1954.

TABLE LV

Yield Summary 1957-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6:1)

Variety	*Yield*
Series L	10.66
S.L.14	9.95
Kenya Selected	8.24
S.L.28	7.97
K.7	7.69
Barbuk Forest	3.15
Columnaris	2.25
Mean	7.13
Least significant difference	
p=0 05	3.30
p=0 01	4.44
p=0 001	5.89
Coefficient of Variation	42.40%

The variability of the yields from this trial permits no distinction to be made between the production of the first five selections in Table LV. The Barbuk Forest and Columnaris types have produced crops significantly less than all other selections.

EMBU AGRICULTURAL INVESTIGATION CENTRE, EMBU DISTRICT

Altitude: 4,900′
Rainfall: 45″

5×5 Latin Square; 9-tree plots; planted 1950.

TABLE LVI

Yield Summary 1953-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6:1)

Variety	*Yield*
S.L.14	11.98
S.L.34	11.35
S.L.28	11.30
N.197	9.94
Kents	9.35
Mean	10.78
No significant difference	
Coefficient of Variation	20.22%

The 1959 yields were disappointingly low and presumably reflect the very dry conditions experienced in the middle of that season. The mean yield was 4.70 cwt. and only S.L.14 yielded significantly more than this in producing 7.09 cwt. This result supports the view that S.L.14 does have a certain resistance to drought although it is known to have no resistance to Leaf Rust.

VARIETY TRIALS IN SOUTHERN PROVINCE

KILUNGU AND MUKAA LOCATIONS, MACHAKOS DISTRICT

Trial A: Mekeku Kyeu *Altitude:* 5,900′ *Rainfall:* 34″
Trial B: Thomas Mbuvi *Altitude:* 5,750′
Trial C: Joel Nzioka *Altitude:* 5,600′

TABLE LVII

1959 yields in cwt. clean coffee per acre using an assumed Cherry: Clean Coffee ratio of 6:1

Varieties	*Trial A*	*Trial B*	*Trial C*
S.L.9	6.75	10.17	—
S.L.14	5.27	8.15	9.63
S.L.17	—	—	10 81
S.L.28	—	8.55	7.07
S.L.34	3.28	8.47	8.97
Kenya Selected Series 'A'	—	8.19	7.19
Kents	2.64	—	—
Ke.20	2.98	—	—
Mean	4.18	8.71	8.73
	No significant difference		
Coefficient of Variation	62.59%	28.07%	39.61%

These three trials are of a 5×5 Latin Square design with single-tree plots. The yields shown in Table LVII are based on data from only one season so that the coefficients of variation are high. The results do indicate the level of cropping which can be expected on young coffee under the local conditions and also draw attention to the appreciably lower yield recorded from the trial at 5,900′ than from the other two trials situated at lower altitudes.

VARIETY TRIAL IN COAST PROVINCE

WUNDANYI. TAITA DISTRICT

Altitude: 5,400′
Rainfall: 53″

6×6 Latin Square; 6-tree plots; planted 1950.

TABLE LVIII

Yield Summary 1954-1959

(Cwt. clean coffee per acre per annum)

Variety	*Yield*
S.L.14	14 06
S.L.34	13 94
S.L.28	13 80
KP.532	12 45
K.7	11 97
S.L.6	11.70
Mean	12 99
	No significant difference
Coefficient of Variation	16.13%

There is no significant difference between the mean yields for the six selections over the six years this trial has been recorded. The average yield of 13 cwt. of clean coffee per acre is very satisfactory by any standards but particularly for an area in which Race I of Leaf Rust is known to be present.

VARIETY TRIAL IN RIFT VALLEY PROVINCE

AGRICULTURAL EXPERIMENTAL STATION, KITALE. *Altitude:* 6,200′
TRANS NZOIA DISTRICT *Rainfall:* 45″

The design of this trial is a 4×4 balanced lattice in five blocks, but a further replicate was planted contiguous with the lattice layout so that the whole can also be considered as six randomised blocks of 16 varieties. This is the form of analysis used to calculate the figures shown in Table LIX.

TABLE LIX

Yield Summary 1958-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6:1)

Variety	*Yield*
Geisha 1	10.58
Geisha 9	9.96
Blue Mountain P.8	9.30
S.L.2	9.26
Blue Mountain N.I	9.03
S.L.34	8.92
S.L.28	8·54
Kenya Selected	8 51
Blue Mountain P.13	8.40
Blue Mountain I.5	8.27
Blue Mountain W.12	8.01
Blue Mountain K.7	7.88
S.L.I	7.71
Kents	7.61
Blue Mountain P.12	7.57
Blue Mountain Q.6	7.29
Mean	8.55
Least significant difference	
p=0 05	1.28
p=0 01	1.70
Coefficient of Variation	13.00%

A remarkable feature of the mean yields for the 1958 and 1959 crops is the high yield from the Geisha selections. Unfortunately the size of coffee beans from both Geisha I and Geisha 9 is very small. Amongst the selections from Blue Mountain coffee it may be seen that P.8 and N.1 have yielded significantly more than P.12 and Q.6.

VARIETY TRIALS IN NYANZA PROVINCE

KEUMBU. SOUTH NYANZA DISTRICT *Altitude:* 6,200′
Rainfall: 80″

9×9 Latin Square; single-tree plots; planted 1951.

TABLE LX

Yield Summary 1958-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6:1).

Variety	*Yield*
S.L.34	11.83
Thorolds	11.82
S.L.14	11.81
S.L.28	11.19
Mocha	10.48
Kenya Selected	10.02
N.100	9.73
S.L.2	9.24
Kents	9.02
Mean	10.57
	No significant difference
Coefficient of Variation	25.66%

With a mean yield of over 10 cwt. of clean coffee per year, the production from this trial is unusually high for the district. N.100 has been reported as showing considerable resistance to Coffee Berry Disease and Thorolds and Kenya Selected were seen to have less Leaf Rust in 1958 than any of the other selections, however, in the yields of coffee there is no significant difference between the nine selections.

KISII. SOUTH NYANZA DISTRICT

Altitude: 5,660'
Rainfall: 67"

7×7 Latin Square; 9-tree plots: planted 1950.

TABLE LXI

Yield Summary 1953-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry: Clean Coffee ratio of 6:1)

Variety	*Yield*
S.L.28	7.80
S.L.14	7.55
Kenya Selected	6.81
Kents	6.42
Thorolds	5.95
KIT 145	5.60
Blue Mountain	5.21
Mean	6.48
Least significant difference	
p=0 05	1.48
p=0 01	1.99
p=0 001	2 64
Coefficient of Variation	20.89%

The variability of the yields from this trial is disappointing considering that there are nine trees per plot and the crops have been recorded for seven seasons. With the exception of 1956 and 1959 the average yields from this experiment have been low. In 1959 the mean yield was 13.30 cwt. of clean coffee per acre with a range between 15 cwt. for the S.L. selections and 9 cwt. for the Blue Mountain coffee. In the aggregate the two S.L. selections have yielded significantly more than Thorolds, KIT 145 or Blue Mountain. The relatively poor performance of Blue Mountain is of interest because it is in the region above Kisii that this type of coffee looks at its best.

MOSOCHO, SOUTH NYANZA

Altitude: 5,200'
Rainfall: 65"

9×9 Latin Square; single-tree plots; planted 1951.

TABLE LXII

Yield Summary 1958-1959

(Cwt. clean coffee per acre per annum using an assumed Cherry : Clean Coffee ratio of 6:1)

Variety	*Yield*
Kents	7.32
Thorolds	7.23
S.L.14	5.25
Kenya Selected	4.32
S.L.28	4.05
N.100	3.68
Mocha	3.31
S.L.34	3.10
S.L.2	1.07
Mean	4.37
Least significant difference	
p=0 05	2.09
p=0 01	2.78
p=0 001	3 63
Coefficient of Variation	50.66%

This trial includes the same nine varieties as the Keumbu plot but here the altitude is 1,000 ft. lower and Leaf Rust is the dominant factor determining coffee production. In August 1958 it was noted that of the 9 Thorolds trees six were almost free of Rust and 7 of the 9 Kents trees showed great Rust resistance. It would appear probable that the very poor yields from the S.L.2 and S.L.34 trees are the result of their high degree of susceptibility to Leaf Rust. There is no significant difference between the mean yields of the five varieties in the middle of Table LXII but Kents and Thorolds have yielded more than all other selections except S.L.14 which has produced significantly more coffee than S.L.34 and S.L.2.

MULCH GRASS INVESTIGATIONS

In the 1957/58 Annual Report from this Station yields of Napier grass mulch over a three-year period were summarised. The Napier grass was grown on a shallow Kikuyu Red Loam soil and the fertilizer treatments were nitrogen (as ammonium sulphate) and three forms of phosphorus fertilizer. In 1958 the fertilizer treatments were re-applied, but in 1959 the trial was terminated and residual yield responses were obtained to the four years of fertilizer application. The results are summarised in Table LXIII.

TABLE LXIII

Napier Grass Yields showing Direct and Residual Responses to Nitrogen and Phosphorus Fertilizers

(Tons dry matter per acre)

Nitrogen treatments	*Phosphorus treatments* (1)	*Double Super-phosphate*	*Hyperphos-phate Reno*	*Basic Slag*	*Means*
Growing season					
—N Long Rains 1958	4.12	6.52	4.98	6.80	5.61
Short Rains 1958	1.45	1.52	1.63	2.45	1.76
Total 1958	5.57	8.04	6.61	7.25	7.37
Residual Fertilizer response					
Long Rains 1959	1.93	2.27	2.02	3.30	2.38
Short Rains 1959	1.16	1.41	1.46	1.44	1.37
Total 1959	3.09	3.68	3.48	4.74	3.75
+N Long Rains 1958	5.94	6.72	5.64	7.04	6.33
Short Rains 1958	1.54	2.23	1.53	1.79	1.77
Total 1958	7.48	8.95	7.17	8.83	8.10
Residual fertilizer response					
Long Rains 1959	2.03	2.28	1.96	2.19	2.12
Short Rains 1959	1.24	1.65	1.33	1.15	1.34
Total 1959	3.27	3.93	3.29	3.34	3.46
Means *Long Rains 1958*	5.03	6.62	5.31	6.92	Least significant Difference p=0.05 p=0.01 No significant difference
Short Rains 1958	1.49	1.87	1.58	2.12	0.41 0.57
Long Rains 1959	1.98	2.28	1.99	2.74	0.59 0.82
Short Rains 1959	1.20	1.53	1.40	1.30	No significant difference

The results for 1958 are in agreement with the three years' results reported previously. Nitrogen, as ammonium sulphate, has not increased the overall yield economically. There is a tendency for a positive interaction of nitrogen with double superphosphate ($42\%P_2O_5$) and in some seasons a negative interaction with the equivalent amount of phosphorus applied as basic slag. Basic slag is a superior form of fertilizer to double superphosphate; hyperphosphate Reno has produced very little, if any, increase in yield. The high yields for the Long Rains 1958 are the result of very good rainfall (=$31\frac{1}{2}$").

There was an appreciable response in the Long Rains 1959 crop to the residual effect of four annual applications of basic slag but only in the absence of nitrogen fertilizer applications. It is concluded from the five years' yields that basic slag followed in order of importance by double superphosphate should be applied to Napier grass crops growing on a Kikuyu Red Loam soil. Response to nitrogen, applied as ammonium sulphate, has been variable. This fertilizer should not be applied with basic slag, but it has interacted positively with double superphosphate.

Napier Grass Production on a Vlei Soil under Camber Bed Cultivation

The Camber Bed cultivation trial which has been reported in detail on previous occasions (Robinson, *et al.*, 1955, 1959) was continued during 1959. Early in the year a subsoiler was run between the Napier grass lines, but this has not restored yields to their former level. The trial will require replanting in 1960 and in preparation for this the grass was ripped out after the Short Rains and no yields were recorded. The yield results for 1959 are summarised in Table LXIV.

TABLE LXIV

Napier Grass Yields and Treatment Effects

(Tons of Dry Matter after the Long Rains 1959)

Treatment per acre	*Yield*	*Treatment effects*
Control	0.58	—
N 2-cwt. ammonium sulphate	0.44	+0.14
P 1-cwt. double superphosphate	1.03	+0.60
C 20 tons cattle manure	1.34	+0.66
NP	1.46	+0.27
NC	1.29	—
PC	1.54	—
NPC	2.00	—
Least significant difference		
p=0.05	0.28	0.14
p=0 01	0.39	0.19
p=0.001	0.54	0.27

The Long Rains 1959 were quite average but low yields are noticeable and may be attributed to the loss of soil structure in the upper 2 ft. of the beds. The subsoiling early in 1959 was not adequate as a means of restoring soil structure and complete replanting after reforming the beds will be necessary.

These beds have carried two crops a year for five years under this system of cultivation and this is probably three years longer than would have been possible with normal flat cultivation.

Soil Analysis of Samples from the Camber Bed Cultivation Trial

Before the 1959 Long Rains soil samples were taken from plots in the Camber Bed cultivation trial at depths of between 0-8" and 8"-16" to determine the effect of fertilizer and manure treatments on the chemical fertility. The results are summarised in Table LXV.

TABLE LXV

Summary of Chemical Analyses

Treatments per acre	*pH*			*K Meq.%*			*Ca Meq.%*			*Mg. Meq%*			*Mn Meq.%*			*P ppm*		
	0-8"	8"-16"	*Mean*	0-8"	8"-16"	*Mean*	0-8"	8"-16"	*Mean*	0-8"	8"-16"	*Mean*	0-8"	8"-16"	*Mean*	0-8"	8"-16"	*Mn.*
Control (1)	4.9	5.1	5.0	0.3	0.2	0.3	5.7	6.8	6.3	1.8	0.5	1.9	0.7	0.5	0.6	6	8	7
N 2-cwt. ammonium sulphate	4.5	5.0	4.7	0.3	0.2	0.3	5.3	5.9	5.6	1.7	1.6	1.7	0.7	0.5	0.6	8	6	7
P 1-cwt. double superphosphate	5.0	5.1	5.0	0.3	0.2	0.3	5.9	7.8	6.9	2.0	2.3	2.2	1.2	1.2	1.2	6	6	6
C 20 tons Cattle manure	5.1	5.1	5.1	1.2	0.4	0.8	6.9	7.9	7.4	3.1	2.5	2.8	0.6	0.4	0.5	10	12	11
NP	4.6	5.0	4.8	0.2	0.1	0.2	6.1	8.5	7.3	1.9	2.1	2.0	1.2	1.2	1.2	7	7	7
NC	4.7	4.9	4.8	0.6	0.4	0.5	6.3	5.6	5.9	2.1	1.8	2.0	0.7	0.8	0.8	7	6	5
PC	5.1	5.1	5.1	1.2	0.3	0.7	7.1	7.4	7.3	2.9	2.3	2.6	1.3	1.3	1.3	11	10	11
NPC	4.6	5.0	4.8	0.5	0.2	0.4	6.5	6.9	6.7	2.3	2.2	2.3	1.3	1.4	1.4	56	8	32
Least significant difference p=0.05			0.1			0.2			1.4			0.4			N.S.			13
p=0.01			0.2			0.3			—			0.6						—

The most marked changed with treatments have been:—

(1) The increase in the degree of soil acidity following applications of ammonium sulphate in each of the rainy seasons.

(2) The substantial increase in exchangeable potassium with cattle manure application, a factor which may account for a large part of the substantial response obtained with Napier grass to this treatment on these soils.

(3) The tendency for ammonium sulphate fertilizer to decrease and double superphosphate to increase the exchangeable calcium level.

(4) The increase in exchangeable magnesium with cattle manure application.

(5) The apparent lack of increase in chemical phosphorus with the application of double superphosphate annually in the Long Rains.

TABLE LXVI

SOIL SAMPLES MARCH 1959

Summary of the Biological Analyses

(Degrees after the angular transformation of the percentage fungal growth compared with the growth in the soil test treatment receiving all nutrients)

Sample depth		*Nitrogen* 0-8″	8″-16″	Mean	*Phosphorus* 0-8″	8″-16″	Mean	*Sulphur* 0-8″	8″-16″	Mean
Treatments (See Table LXV)	(1)	0.0	0.0	0.0	0.0	0.0	0.0	63.7	63.5	63.6
	N	14.4	0.0	7.2	0.0	0.0	0.0	68.2	70.7	69.4
	P	13.4	14.4	13.9	0.0	0.0	0.0	64.4	58.3	61.4
	C	0.0	0.0	0.0	0.0	0.0	0.0	66.6	59.1	62.8
	NP	8.3	0.0	4.2	0.0	0.0	0.0	60.9	74.6	67.8
	NC	13.7	14.0	13.8	0.0	0.0	0.0	74.3	55.0	64.6
	PC	0.0	0.0	0.0	28.8	0.0	14.4	72.3	59.7	66.0
	NPC	12.7	29.6	21.1	32.3	0.0	16.2	66.3	69.3	67.8
Least significant difference	p=0 01			N.S.			10.7			N.S.
	p=0.001						14.2			

Biological analyses for nitrogen are very variable and differences are not significant. Biological sulphur values are on the low side but relatively consistent and phosphorus plus cattle manure has raised the biological phosphorus values.

Overall treatment effects in the top 16″ of the soil profile are shown in Table LXVII and every treatment has had some marked effect on the soil fertility.

TABLE LXVII

Summary of Significant Fertilizer and Manure Effects on the Results of Chemical and Biological Analyses

	Chemical Analysis					*Biological Analysis (Degrees)*	
Treatments (See Table LXV)	pH	K *Meq.%*	Ca *Meq.%*	*Mg Meq.%*	*P ppm*	*N*	*P*
N effect	—0.3***	—0.2**	—	—0.4***	—	+10.9*	—
P „	—	—	+0.8*	—	—	—	+10.3*
C „	—	+0.4***	—	+0.5***	+7.9*	—	+10.3*
NP inter-action	—	—	—	—	+6.7*	—	—
NC „	—	—0.2**	—	—	—	—	—
PC „	—	—	—	—	+ 6.9*	—	—
NPC „	—	—	—	—	+ 6.8*	—	—
Levels of Statistical significance	p=0.05*;	p=0.01**;		p=0.001***			

In view of the effect of ammonium sulphate on soil pH and the values for exchangeable potassium and magnesium it is concluded that it would be advisable to apply nitrogen in the form of urea, ammonium sulphate nitrate or calcium ammonium nitrate.

Outstanding overall effects of the treatments are those of cattle manure on potassium, magnesium and phosphorus and double superphosphate on calcium and phosphorus. Cattle manure and double superphosphate have interacted together positively in raising both chemical and biological phosphorus levels.

References

ROBINSON, J. B. D., T. R. BROOK and H. H. J. de VINK, 1955. *E. Afr. agric. J.*, **21**, 69.
ROBINSON, J. B. D., H. R. EVANS and T. R. BROOK, 1959. *E. Afr. agric. J.*, **24**, 184.

VEGETATIVE PROPAGATION STUDIES

Mist Propagation

The first results obtained with the mist propagator are most encouraging. Good to excellent rooting occurs within approximately 15 weeks. With the mist propagation technique, the use of hormones proved to be superfluous in several experiments but sometimes a better root system was produced with hormones than without. The vertical roots produced in the mist propagator are mostly very brittle and often short of laterals. As sometimes up to 20 thick verticals are formed, it is doubtful if all these roots will continue to grow and observations are being made to study this question.

Problems to be investigated in more detail are: the production of secondary and tertiary roots, the frequency of spraying, excessive leaching of the leaves, the optimum light intensity and hardening off of rooted cuttings.

Experiments have now been initiated to discover the best method of 'hardening off' rooted cuttings from the mist propagator. Two series of cuttings have been transplanted directly from the propagator into the nursery beds without difficulty. If the technique for establishing the rooted cuttings in the nursery is perfected it should be possible to produce plants of sufficient size for planting into the field after a period of about 12 months.

Composts for Rooted Coffee Cuttings

This experiment has now been completed. The best results were obtained by using a compost consisting of 1 part vermiculite, 1 part coffee hulls and 2 parts of coarse sand. Excellent results were also obtained using a compost consisting of equal volumes of coffee hulls and coarse sand. Inferior results were obtained when vermiculite was used alone and when mixed with an equal volume of coffee hulls or coarse sand.

AGRICULTURAL CHEMISTRY

SOIL NITROGEN STUDIES

During late 1957 and early 1958 a trial was carried out to examine the relationship between chloride and nitrate ions added to the soil profile. The primary objective was to determine if the movement of these ions was correlated and if so, whether an upward movement of nitrate-N took place during dry weather. The results of this work were summarised briefly in a previous report (1).

In May 1959, the plots in this trial were sampled at intervals down to 10 feet, to obtain information about the distribution of the nitrate and the chloride ions with depth. Following the publication of a paper by Bremner (2), some of these soil samples were also examined to provide preliminary information on the quantity and distribution of fixed ammonia-N in the Kikuyu red loam coffee soil profile.

Distribution of nitrate and chloride ions within a 10-ft. coffee soil profile

About 18 months after the application of 100 lb. nitrogen per acre, in the form of ammonium chloride, soil samples were taken at vertical intervals of a foot, down to nine and a half feet, in a Kikuyu red loam coffee soil. Three replications of treated and untreated soil profile were sampled; the plots had lain fallow during the interval between nitrogen application in late November 1957 and sampling in early May 1959. The results, in parts per million of oven dry soil, are summarised in Table LXVIII; the mean values for nitrate-N and chloride found in the untreated, control plots have been subtracted from the mean figure for the ammoninm chloride treated plots, for each sample depth.

TABLE LXVIII

Vertical distribution of nitrate-N and chloride in a Kikuyu red loam coffee soil. (Difference data; NH_4Cl treatment —control.)

Soil Sample Depth inches	*Nitrate-N (ppm)*	*Chloride (ppm)*
0-3	3.4	5.5
3-6	2.9	—4.1
6-9	17.9	—14.8
9-12	—1.4	—0.3
16-20	5.2	—1.9
28-32	36.3	96.6
40-44	27.9	44 6
52-56	11.7	13.9
64-68	32.0	34.5
76-80	41.0	42.6
88-92	10.1	—3.8
100-104	—7.1	7.0
112-116	10.9	—0.6

Correlation Coefficient $r = +0.75^{***}$

There is a highly significant correlation between the nitrate-N and chloride ions with depth. Furthermore, the distribution of the difference values for chloride shows that nitrogen, derived from the ammonium chloride application made in November 1957 and present now as nitrate-N, is concentrated between 28 and 80 inches. It is distributed with a marked twin peak accumulation. (N.B. Full and detailed data have not been reported here. Both nitrate-N and chloride distribution down the profile showed highly statistically significant differences with sample depth changes.)

The twin peak accumulation might represent the leaching influence of the Long Rains 1958 (31″) and the first half of the Long Rains 1959 (8½″). The Short Rains 1958 were a failure and at no time was there any appreciable degree of leaching below two feet. The added nitrogen was not present in the profile as either exchangeable or fixed ammonia-N (see following section), in addition to the natural nitrate-N found. However, Kjeldahl nitrogen figures were much higher at all depths throughout the soil profile and it is concluded therefore, that some of the added nitrogen was present in the profile in an organic form. (The overall mean Kjeldahl-N values for the control and the ammonium chloride treatments are given in the following section).

Fixed Ammonia-N in a Kikuyu Red Loam Coffee Soil Profile

Soil samples were taken in May 1959 to a depth of 10 feet, at intervals of 1 foot. There were three replications of control and nitrogen treated (100 lb. nitrogen per acre applied in November 1957) plots; samples from the 0-3″; 16″-20″; 40″-44″; 76″-80″; and 112″-116″ profile depths only were analysed for this study. The soil is a lateritic clay loam, free draining, with a Kaolinitic type of clay in a proportion of 55-60% in the topsoil, increasing to 70% with depth. It was not expected that very much fixed ammonia-N would be found in this type of clay soil (2). Results are summarised in Tables LXIX and LXX.

TABLE LXIX

Mean values for Kjeldahl-N, fixed and exchangeable ammonia-N in a 10-foot soil profile

Treatment	*Kjeldahl-N (ppm)*	*Fixed NH_3-N (ppm)*	*Exchangeable NH_3-N (ppm)*
Control	875(15)	45.1	6.5
100 lb. N (1957).	1647	43.3	7.0
L.S.D's (15)	143***	N.S.	N.S.

TABLE LXX

Changes in Kjeldahl-N, fixed and exchangeable ammonia-N with profile depth.

Soil Sample depth. inches	*Kjeldahl-N*	*Fixed NH_3-N*	*Exchangeable NH_3-N*
0-3	1733(6)	58.2	8.2
16-20	990	43.5	7.0
40-44	593	40.4	5.0
76-80	430	34.6	7.5
112-116	370	40.9	5.6
L.S.D.s(6)	121*	8.5*	N.S.
	166**	11.6**	—
	226***	15.8***	—

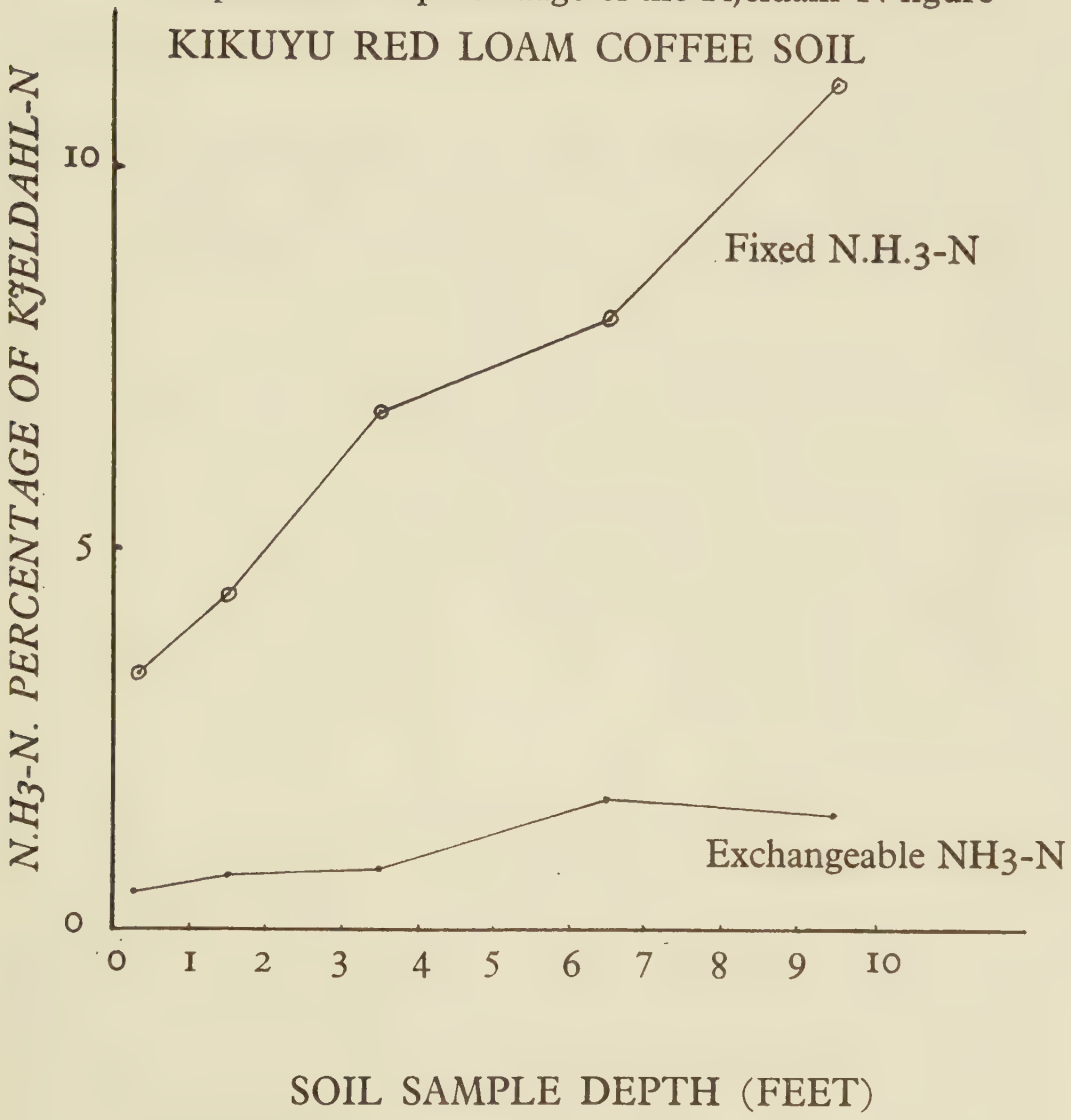
The Kjeldahl-N mean for the ammonium chloride treatment is very significantly higher, overall, than the control value. Since neither the fixed nor the exchangeable ammonia-N differs significantly with treatments it is concluded that this difference is the result of a change in the added nitrogen to an organic form.

Kjeldahl-N figures decrease with soil depth, as might be expected, but the fixed ammonia-N content in the soil, which decreases substantially from the 0-3″ to the 16″-20″ sample depths, remains the same throughout the rest of the soil profile. Exchangeable ammonia-N does not differ significantly between the different sample depths. Fixed ammonia-N when expressed as a percentage of the Kjeldahl-N value for each depth interval, increases steadily down the profile to a little more than 10%, as shown in Figure I. When the exchangeable ammonia-N figures for each depth interval are expressed as a percentage of the appropriate Kjeldahl-N figure, they also show a small increase with depth.

Fig. 1 CHANGES IN FIXED AND EXCHANGEABLE AMMONIA NITROGEN WITH SOIL DEPTH

Expressed as a percentage of the Kjeldahl-N figure

KIKUYU RED LOAM COFFEE SOIL



NAPIER GRASS MULCH AND SOIL FERTILITY

Field trials show that substantial coffee yield increases are obtained in response to mulching with Napier grass (*Pennisetum purpureum K. Schum*). Research has proved that increased rainfall acceptance, soil moisture conservation and soil structure improvement all play a part in bringing about this crop increase. Hitherto, the value of Napier grass mulches in raising the chemical soil fertility has been largely accepted without many very strict measurements of this effect being made, with the exception of a study of the relationship between Napier grass mulch and magnesium unbalance (3).

A study of the influence of Napier grass mulches on chemical soil fertility factors was undertaken during 1959/1960. Comparative soil analyses were carried out; tomato growth assessments by the Webb micro-pot technique (Chenery adaptation) have been made and comparative analysis of coffee leaf samples have been included. All this work was undertaken on the Kikuyu red loam coffee soil.

Comparative soil analysis.

Topsoil samples were collected from unmulched and Napier grass mulched plots in the Mulch and Soil Regeneration Trial (Expt. I) and Manurial Trial IV (Expt. II). Napier grass mulch had been applied consistently and annually for eleven years and five years respectively in these two trials. The results of chemical and biological analysis are summarised in Table LXXI. Experiment I compared values for 0-4″, 0-8″ and 0-12″ topsoil samples and Experiment II was confined to a comparison of 0-8″ topsoil samples only. The overall growth response with tomato seedlings in the pot tests are included in the Table to emphasise the comparisons.

TABLE LXXI

Comparative analysis of topsoil samples ± Napier grass mulch.
(Expt. 1.)

Factor	*Napier Grass Mulch*			*No mulch*		
	0-4″	0-8″	0-12″	0-4″	0-8″	0-12″
Growth %	100	85	39	25	27	12
pH	6.7	6.1	5.7	5.4	6.4	5.3
Potassium (meq%)	3.1	2.8	2.2	1.5	1.5	1.2
Calcium (meq%)	7.8	6.2	3.2	7.0	7.0	5.2
Magnesium (meq%)	5.7	5.4	3.4	3.8	3.0	2.5
Phosphorus (ppm)	40	35	15	15	13	10
Nitrogen † (%)	26	38	3	50	43	37
Phosphorus† (%)	84	67	56	54	61	50
Sulphur (%)†	74	84	84	93	93	87

Notes: 1. Chemical and biological(†) analyses were carried out by the Scott Agricultural Laboratories, Dept. of Agriculture, Kenya.
2. Biological analyses (*Cunninghammella Blakesleeana* fungus test) are expressed as a percentage of the + All nutrient treatment.
3. Tomato growth is expressed as a percentage of the 0-4″, + Mulch sample, overall nutrient treatments, 10 and experimental replications, 3.

Tomato seedling growth is much greater in the test period on the mulched soil samples, although there is an appreciable and expected difference with sample depth. The unmulched soil has supported significantly less growth at all sample depths. At least part of the soil effect can be attributed to a better physical condition and therefore a greater aeration of the soil. The coarser, more aggregated appearance of the mulched soil was apparent throughout the test.

The effect of the mulch on pH and chemical fertility is most noticeable in the top 0-8″ of the soil profile. Mulch has decreased soil acidity, increased potassium, magnesium and phosphorus (chemical and biological). The nitrogen supply in the soil (availability) has apparently been decreased by the mulch in terms of the biological test results. There is apparently an adverse effect in terms of nitrogen availability over the short term (2 day) duration of the test. A similar situation is apparent for sulphur also.

The results obtained in the second experiment where Napier grass mulch had been applied regularly for five years prior to sampling, are summarised in Table LXXII.

TABLE LXXII

Comparative analysis of topsoil (0-8") samples ± Napier grass mulch (Expt. II).

Factor	*Napier Grass Mulch*	*No Mulch*
Growth %*	100(30)	65
pH	6.8	6.1
Potassium (meq%)	3.7	2.1
Calcium (meq%)	12.6	13.8
Magnesium (meq%)	5.0	4.2
Phosphorus (ppm)	40	36
Phosphorus (%)†	62	62

Notes: * Tomato growth expressed as percentage of the 0-8", + mulch soil, overall nutrient treatments, 10 and experimental replications, 3. (L.S.D. 2 means of 30=8%***)

† Refer note 1 under Table IV.

In this experiment too, tomato growth was very much greater in the mulched soil; the mulch had decreased soil acidity and increased potassium and possibly magnesium slightly. In this trial phosphorus values (chemical and biological) were relatively high in the unmulched soil. This is attributed to Uganda rock and soda phosphate applications prior to the sampling, when the area had been under a previous experiment.

It is important to note in relation to the tomato seedling growth results reported in the next section, that the general level of chemical soil fertility is greater in the soil samples from Expt. II, i.e. Manurial Trial IV area, than it is in the soil from Expt. I, i.e. Mulch and Soil Regeneration Trial, in the absence of the Napier grass mulch treatment.

Tomato seedling growth in the micro-pot tests.

Details of the tomato growth recorded in the two experiments are summarised in Table LXXIII.

TABLE LXXIII

Summary of tomato seedling growth in a Kikuyu red loam coffee soil ± Napier Grass Mulch. (Growth as percentage.)

Treatment	*Napier Grass Mulch*		*No Mulch*	
	Expt. I	*Expt. II*	*Expt. I*	*Expt. II*
	a	b		
+ all nutrients	100	100	28:100†	74:100
— All nutrients	60	69	12:42	43:588
— Nitrogen	64	70	22:79	60:82
— Phosphorus	69	69	8:29	44:59
— Potassium	65	97	20:70	49:66
— Sulphur	64	71	24:86	64:87
— Magnesium	80	98	24:84	60:81
— Calcium	74	93	25:88	61:81
— Trace elements	67	100*	18:64	57:77
— Chloride	77	100*	25:88	58:78
Overall means		+Mulch		—Mulch
Expt. I	c	100		29
Expt. II	d	100		65

L.S.D's Expt. I a—2 means of 9 =11%*; 15%** (%+M,+all treatment)
c—2 means of 90 =9%*** (%+M over all treatments)
Expt. II b—2 means of 3 =9%*; 13%**
d—2 means of 30 =5%***

Notes: 1. Growth is expressed as a percentage of the + mulch, + All nutrients treatment in both trials.
2. † The second figure appearing thus:100 represents growth as a percentage of the + mulch, + All nutrients treatments.
3. Growth is measured as dry matter weight of the aerial portion of the tomato seedling at harvest.

It is apparent that Napier grass mulch has effected overall growth increases in both experiments. Undoubtedly, in so far as the tomato plant is concerned, the increased phosphorus level in the mulched soil (Expt. I) has played a big part in increasing the growth. Consideration of the no mulch growth values for experiment I in particular, where they are expressed as a percentage of the + mulch, + All nutrient treatment, shows a severe phosphate deficiency and a shortage of available nitrogen. A phosphorus shortage is not obvious in experiment II for the reason stated in the previous soil analysis section and because the difference between growth for ± mulched soil is not so large.

Influence of a Napier Grass Mulch on comparative coffee leaf analysis

Samples of leaves were taken at monthly intervals, from April to December 1959, from bearing primaries in the Mulch and Soil Regeneration Trial; comparative samples were taken from unmulched and mulched plots (i.e. those receiving a standard mulch of Napier grass prior to the Long Rains). These were the same plots which were sampled for the first pot experiment reported above. Each set of samples included corresponding pairs from plots which receive sodium nitrate and urea fertilizer. The mean leaf analysis values for all treatments with and without Napier grass mulch over the whole sampling period are summarised in table LXXIV.

TABLE LXXIV

Mean leaf† analysis values ± Napier Grass Mulch. (% of element in leaf dry matter.)

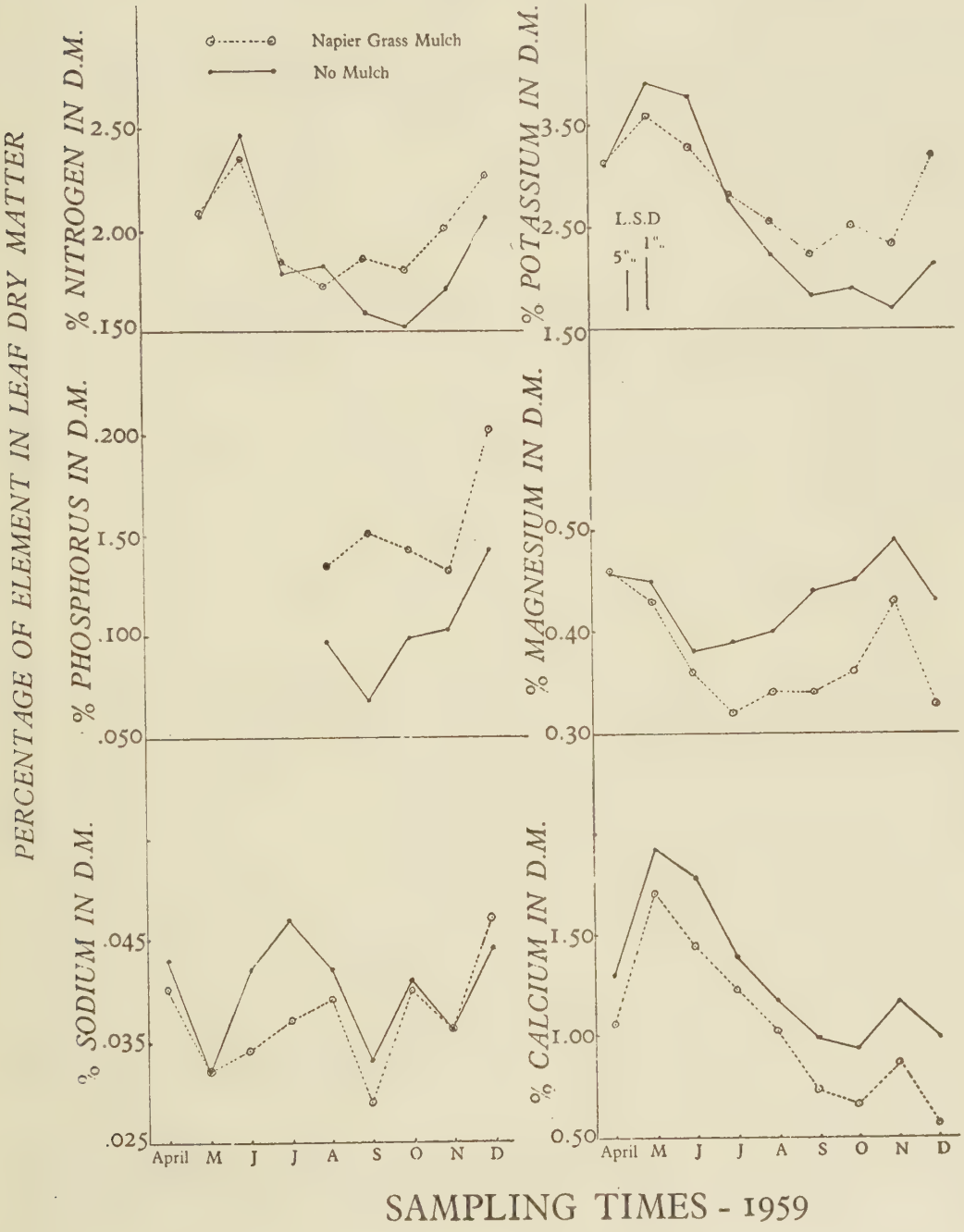
Treatment	*N*	*P*	*Na*	*K*	*Ca*	*Mg*
No mulch	1.972	.1086	0 044	2.56	1.29	0.44
Napier grass mulch	2.014	.1568	0.039	2.72	1.09	0.38
L.S.D's	N.S.	.0343***	.008*	0.15*	0.14*	0.05*

N.B. † Youngest mature leaf pair.

Over the whole sampling period the Napier grass has significantly increased the mean levels of phosphorus and potassium, and decreased the mean levels of sodium, calcium and magnesium. The decrease in leaf magnesium is related to increased uptake of potassium (3); this increase in leaf potassium may also be one reason for lower sodium and calcium leaf values. However, it is known that the content of calcium in the coffee leaf increases with the age of the leaf (4), and that more growth takes place in mulched than in unmulched coffee (5). This may be a reason for the lower leaf calcium figure (dilution of mineral element concentration by increased growth), since the soil analyses reported in the previous section do not reveal any appreciable increase with Napier grass application. Yet another factor, that of yield, may have influenced these results; the approximate mean yield for the no mulch treatment was 13.5 cwt. and that of the mulch treatment was 16.6 cwt. of clean coffee per acre.

A consideration of the mean values for each sampling date (leaf samples were collected towards the end of each month) for the plus and minus Napier grass mulch plots only reveals some interesting changes with time, see Figure II. Leaf nitrogen means are apparently higher in mulched coffee during the dry months, a feature which is attributed to the longer period of available topsoil moisture together with higher soil nitrate levels (6). Leaf phosphorus values are very much higher in the mulched coffee, a finding which is in agreement with work carried out in Brazil (7). This is undoubtedly an effect of increases in soil phosphorus levels following mulching (refer to previous section), but may also be attributable partially, to other factors, e.g. a longer period of available topsoil moisture under the mulch and the presence of a higher level of organic phosphorus in the topsoil which may be more freely available to the coffee. Leaf sodium levels are lower for the mulched coffee, although the changes with time are similar for ± mulch. Leaf potassium values are markedly influenced by the mulch. During and just after the Long Rains leaf potassium values are higher in the absence of mulch despite the higher exchangeable potassium level shown to be present in the topsoil under the mulch. The leaf potassium level in the unmulched coffee then falls off rapidly through the dull, cool winter months whilst the crop is maturing, to a much greater degree than it does in the mulched coffee; in October, November and December it is significantly lower. Higher crop yield from the mulched

Fig. II THE INFLUENCE OF NAPIER GRASS MULCH ON LEAF ANALYSIS VALUES



coffee has not reduced the potassium level in the leaf to a very serious degree. More rapid growth might account for lower values in the early period of this study in the mulched coffee whereas lack of available topsoil moisture in the unmulched coffee may have accounted for the more rapid decrease in leaf levels during the dry period whilst the crop was maturing. But this does not explain why the leaf potassium levels did not approach one another more closely in November and December with the onset of the Short Rains.

The changes in leaf potassium levels are even more interesting when they are considered in relation to the magnesium curves. In the presence of the Napier grass mulch, leaf magnesium values are appreciably lower. In the presence of a mulch, and as the crop matures in June–July, leaf potassium levels increase while magnesium levels decrease. Thereafter the ratio between levels of leaf potassium and magnesium become wider with time in the presence of the mulch. This is an illustration of the K : Mg unbalance, which usually results in symptoms of visual magnesium deficiency in the coffee leaves as described previously (3).

Although leaf calcium values are consistently lower in the Napier grass mulch treatments the changes in leaf levels with time were very closely parallel. Suggested reasons for the lower values with mulch have already been put forward.

It is thus evident from these results that a Napier grass mulch, applied regularly to coffee on an annual basis, profoundly influences the leaf composition as well as the crop yield.

These graphs emphasise the importance of the time in the year at which leaf samples are taken for analysis in relation to the analytical values obtained. Samples taken in the September–October period will provide an estimate of the lowest leaf levels to be found for nitrogen, potassium, phosphorus and calcium, but magnesium values are apparently lowest following the Long Rains, during the dull cool winter months of July–August. The September–October period is dry, hot and sunny, and the trees in the Ruiru District are usually carrying the bulk of the crop through the latest stages of maturation and ripening. It may be possible to correlate the low leaf values found in this period with the current season's crop or more probably, the following season's crop.

THE INFLUENCE OF NITROGEN FERTILIZER ON LEAF NITROGEN IN THE PRESENCE AND ABSENCE OF MULCH

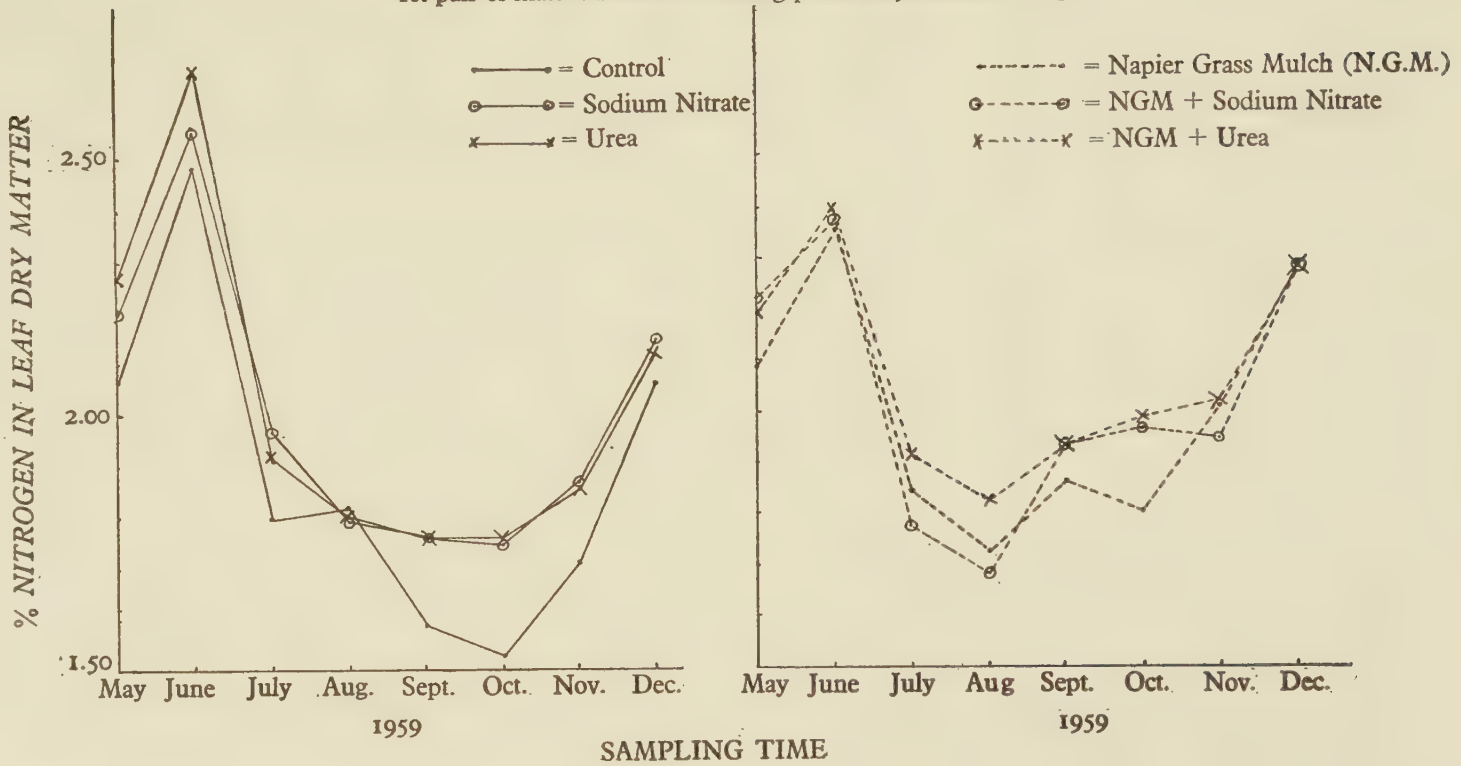
Leaf samples were collected from bearing primaries at monthly intervals during the greater part of 1959, from some of the nitrogen fertilizer plots and nitrogen fertilizer plus Napier grass mulch plots in the Mulch and Soil Regeneration Trial. Whilst none of the treatment differences differed significantly in the statistical analysis of the figures, overall changes in leaf nitrogen with time were significantly different and two other trends are worthy of some comment (refer to Fig. III).

With the onset of dry topsoil conditions (July) in the absence of a mulch, leaf nitrogen figures fell substantially and by September it would seem that the nitrogen fertilizer treatments had increased leaf nitrogen, a particularly noticeable feature over the September–November period. The general shape of the curves for leaf samples from the mulched coffee is markedly different from that for unmulched coffee in the absence of nitrogen fertilizers. With mulch, the lowest leaf nitrogen levels are attained in August. Thereafter, levels rise. This increase coincides with the maturation of the crop and with very dry weather. Further, there is no appreciable difference between mulch alone and mulch plus the nitrogen fertilizer; the presence of mulch has apparently decreased peak leaf nitrogen values during the Long Rains in comparison with the unmulched coffee. These differences may be attributed to a number of different factors namely, a longer period of available topsoil moisture and a higher level of soil nitrate under the Napier grass mulch during dry weather (10); a difference in growth rate and possibly in crop yield. The last named condition is unlikely since, in this trial, the approximate yields for the different treatments were Control, 11.7; Urea, 14.3; Sodium nitrate, 14.4; Mulch, 16.3; Mulch + urea, 17.3 and Mulch + Sodium nitrate, 16.2 cwt. of clean coffee per acre respectively, i.e. higher yields in the presence of a Napier grass mulch.

The most noticeable difference is the manner in which the presence of a Napier grass mulch has masked leaf nitrogen increase in response to fertilizer application. It might be that split fertilizer application during the Long Rains will result in a detectable increase over and above the Napier grass mulch effect, since yield increases with split application in the presence of a mulch have been confirmed in the early results from one field trial (8).

Fig. III *LEAF NITROGEN LEVELS ± NITROGEN FERTILIZER; ± NAPIER GRASS MULCH*

1st pair of mature leaves on bearing primaries; means of 2 reps.



SODIUM NUTRITION STUDIES

When a detailed review and evaluation of fertilizer responses in the several experiments on this Station was made early in 1959 it was noted that, in the absence of a Napier grass mulch, sodium nitrate fertilizer had been significantly more efficient than either ammonium sulphate or ammonium nitrate (9). Similar rates of nitrogen per acre (46 lb.), applied as these three different forms of fertilizer, produced very different yield increases over a period of eight seasons. Apart from the possibility that the coffee tree prefers to have nitrogen supplied directly as nitrate there were at least three other factors which required consideration. The effectiveness of sodium nitrate in maintaining a high level of available nitrate nitrogen in the soil, for a sustained period after application under certain conditions of natural rainfall, has been demonstrated in the results of work reported recently (10). It has also been shown that the regular application of sodium nitrate fertilizer decreases soil acidity and that the level of exchangeable soil sodium is increased (refer to soil analysis data under Mulch and Soil Regeneration Trial in this report). The possibility that uptake of sodium by the coffee tree might be in some way connected with yield increases was also considered and, during a large part of 1959, leaf samples were collected regularly from the trial in which the sodium nitrate treatment occurs (Mulch and Soil Regeneration Trial). One set of feeder root samples was also collected from the plots in August to examine the effect of sodium nitrate on the base content of these roots.

Root Sample Analysis

Samples of feeder roots were collected at about four inches below the soil surface, from two trees at random in each plot. The position of sampling was $3\frac{1}{2}$ feet away from a tree along a diagonal between two trees (Spacing was 10 ft. by 10 ft. square). After washing to remove soil they were analysed for sodium, potassium, calcium and magnesium. The results are summarised in Table LXXV.

TABLE LXXV

Coffee Feeder Root Analysis

		Control		*Sodium Nitrate*		*Urea*		*Means*	
		a	*b*	*a*	*b*	*a*	*b*	*a*	*b*
No mulch	Na	0.040(2)	1.7	0.091	4.8	0.042	2.1	0.058(6)	2.8
	K	1.33	34.1	1.16	35.6	1.19	34.7	1.23	34.8
	Ca	0.67	33.5	0.53	31.8	0.60	34.1	0.60	33.1
	Mg	0.37	30.5	0.28	27.7	0.31	29.0	0.32	29.2
	(c)		100.2		83.8		88.5		90.8
Napier grass mulch	Na	0.056	2.2	0.112	3.9	0.049	2.3	0.072	2.8
	K	1.88	42.4	1.92	39.6	1.47	39.9	1.76	40.7
	Ca	0.70	30.7	0.73	29.3	0.63	33.3	0.69	31.1
	Mg	0.34	24.6	0.41	27.2	0.28	24.4	0.34	25.2
	(c)		114.0		124.8		94.4		111.0
Means	Na	0.048(4)	2.0	0.102	4.3	0.046	2.2		
	K	1.61	38.4	1.54	37.9	1.33	37.5		
	Ca	0.69	32.1	0.63	30.2	0.62	34.1		
	Mg	0.36	27.6	0.35	27.7	0.29	26.3		
L.S.D's	Na	2 means of 4 = 0.046**%. (Type of Nitrogen fertilizer).							
	K	2 means of 6 = 0.38*% (+vs. —mulch)							
	Ca	2 means of 6 = 0.09*% (+vs. —mulch)							
	Mg	2 means of 2 = 0.09*%; 0.13**% (Mulch × nitrogen fertilizer interaction).							
	(c)	2 means of 6 = 16 meq/100gms (+vs —mulch).							

Notes: 1. a = percentage of the element in the root dry matter.
b = The element is expressed as a percentage of the sum of Na + K + Ca + Mg after conversion to milliequivalents/100gms dry matter of each individual element.

2. Na = Sodium; K = Potassium; Ca = Calcium; Mg = Magnesium.
(c) = Sum of Na + K + Ca + Mg in milliequivalents/100gms of root dry matter.

These results show that there were some very interesting and statistically significant differences between the root samples at the time that they were taken. The total content of Na + K + Ca + Mg in the feeder roots was significantly greater in the presence of mulch over all the nitrogen treatments, to the extent of + 22%. This increase is largely attributable to a higher potassium content.

The sodium content of the feeder roots is similar for the control and the urea fertilizer treatments but is significantly greater in the sodium nitrate treatment. The sodium nitrate fertilizer has also influenced the level of magnesium in the roots in the presence of the mulch and has apparently counteracted the effect of higher exchangeable soil potassium values under the mulch. Feeder root magnesium content is higher in the mulch plus sodium nitrate treatment than it is in the mulch, plus urea treatment. Both calcium and potassium in the feeder roots (averaged over the nitrogen treatments) have increased with mulch application.

Leaf Sample Analysis

From April to December 1959, regular monthly leaf samples were collected from the same plot treatments as the feeder root samples. The overall mean leaf values are summarised in Table LXXVI. Samples consisted of the 1st mature leaf pair from bearing primaries.

TABLE LXXVI

Mean leaf analysis values for Sodium, Potassium, Calcium and Magnesium for the period April—December 1959. (% *of element in leaf dry matter*)

		Control	*Sodium Nitrate*	*Urea*
No mulch.	Na	0.040(18)	0.052	0.039
	K	2.60	2.33	2.75
	Ca	1.29	1.25	1.32
	Mg	0.43	0.45	0.42
Napier grass mulch.	Na	0.037	0.045	0.036
	K	2.85	2.65	2.66
	Ca	1.03	1.09	1.14
	Mg	0.38	0.38	0.37
Means	Na	0.038(36)	0.048	0.037
	K	2.72	2.49	2.70
	Ca	1.16	1.17	1.32
	Mg	0.40	0.41	0.39
L.S.D's	Na	2 means of (18)=0 008*%; 0.013**%.		
	K	2 means of (36)=0.24*%.		
	Ca	Not significant.		
	Mg	Not significant.		

Over the entire sampling period sodium nitrate fertilizer has increased the leaf sodium and decreased leaf potassium content significantly. The variation with sampling time ± mulch, is shown in Figure IV.

It is apparent that, in the presence of Napier grass mulch, changes in leaf values are often less extreme, a feature which applies particularly to the potassium and sodium curves; in some cases (e.g. potassium and sodium) differences between nitrogen treatments are diminished in the presence of mulch.

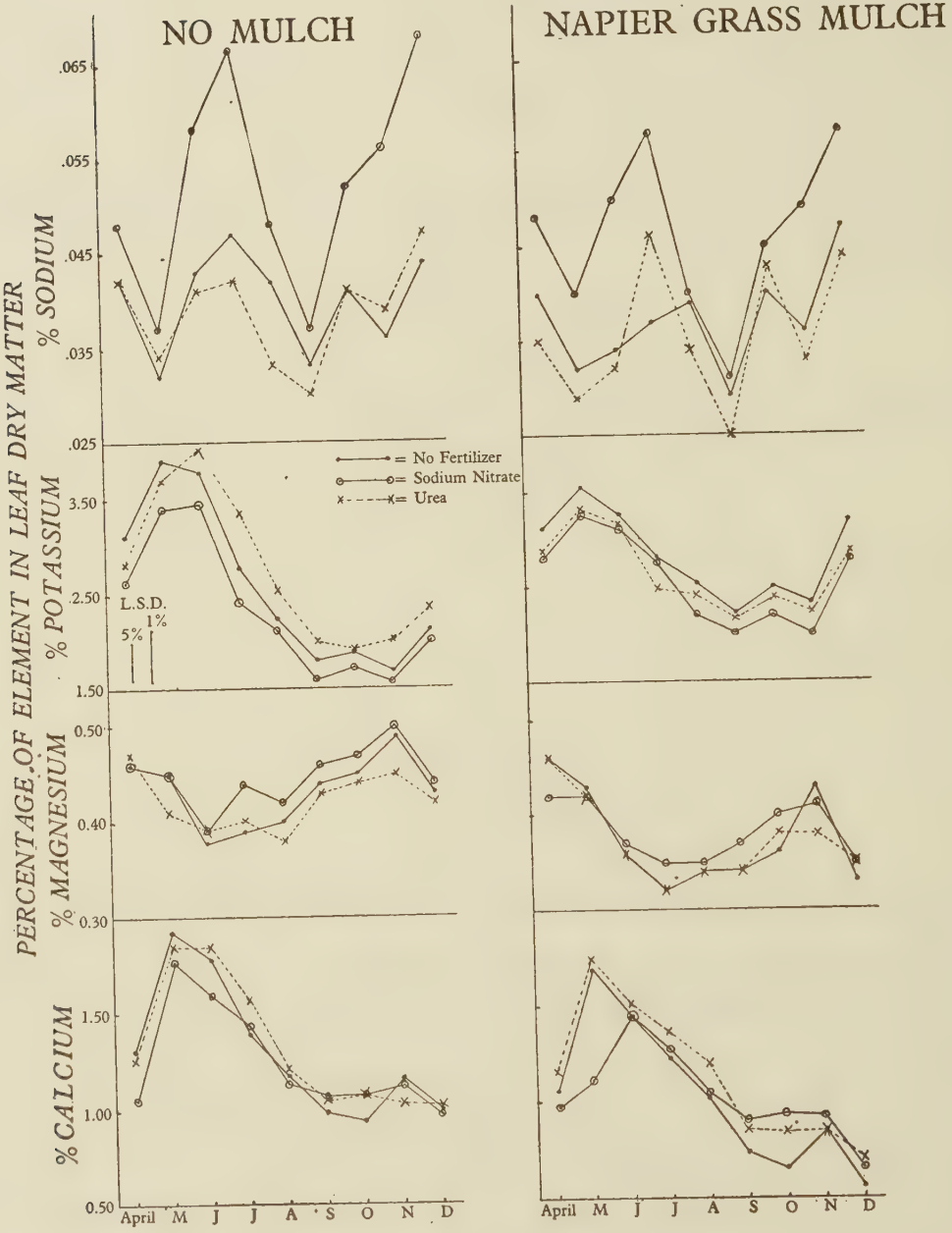
Sodium nitrate fertilizer has raised the leaf sodium values at all sampling times but has not changed the shape of the curves.

In the absence of mulch, sodium nitrate has significantly decreased the leaf potassium values in comparison with urea. This effect is present, but not to such a degree, with the Napier grass mulch and again, there is no change in the general shape of the curves.

Sodium nitrate has consistently raised the leaf magnesium levels particularly during the months of July-October inclusive, relative to the urea treatment. This difference is apparent both in the presence and absence of the mulch.

Leaf calcium values do not show any markedly consistent differences with time, between the treatments.

Fig IV THE INFLUENCE OF SODIUM NITRATE FERTILIZER ON LEAF SODIUM, POTASSIUM MAGNESIUM AND CALCIUM LEVELS



SAMPLING TIMES — 1959.

Evidence is presented here which shows that uptake of sodium by the coffee tree has followed the use of sodium nitrate fertilizer. This uptake has reduced the leaf potassium and raised the leaf magnesium levels during the July-October period when crop maturation is taking place. These effects are less obvious in the presence of a Napier grass mulch; the increased efficiency of nitrogen applied as sodium nitrate fertilizer is only significant in the absence of a Napier grass mulch. Since the coffee in this trial is subject to magnesium: potassium unbalance it is possible that the uptake of sodium and its relationship to potassium and magnesium levels in the coffee leaf, may have influenced yields favourably. The relationship between the value of sodium versus potassium in coffee tree nutrition is being studied at present by means of the micro-pot test technique.

ANALYSIS OF COFFEE SOILS

The soil analysis project described previously (16) was continued during 1959/1960. Summaries of the results obtained with soil samples taken in the manurial and other cultural trials in the Coffee Research Station appear in this report individually under the appropriate sections.

The results of routine coffee plantation soil analysis* have been summarised in a preliminary report for four of the main coffee Districts situated East of the Rift Valley. Figures for pH, exchangeable potassium, calcium, magnesium, chemical phosphorus and biological nitrogen analyses have been grouped in a series of narrow ranges of values for each of the districts and the number of such analyses in each group for each district has been calculated as a percentage of the total number of samples analysed from each district. This has been carried out for the topsoil (0-8") samples only and enables the following comparisons to be made:—

(1) A comparison of the quantitative distribution of figures in a certain narrow range group between Districts.

(2) A comparison of the overall means between Districts.

(3) It permits any particular plantation to compare analytical values for samples taken on that plantation with the District values.

It had been hoped that the data would provide a means of comparing the influence of mulching on soil fertility, on a wide scale. A preliminary consideration of the data showed however, that field sampling lacked the necessary precision and detail for this to be done with accuracy. Therefore this problem has been the subject of a separate and intensive investigation the results of which are recorded elsewhere in this report.

The distribution histograms for Kiambu, Ruiru, and Thika (all Kikuyu red loam coffee soils) and for Donyo Sabuk District (some soils of mixed Volcanic and Basement Complex origin) are shown in Figures V and VI. These results are based on the analysis of the following numbers of soil samples; Kiambu—54; Ruiru—179; Thika—155; and Donyo Sabuk—34.

The individual overall mean values for each District, together with the standard deviation and an indication of statistically significant differences are summarised in Table LXXVII.

* *Footnote :* Analytical methods; pH by the soil paste method; chemical analyses on a H_2SO_4—HCl soil extract (after A. Mehlich); nitrogen by *Cunninghamella Blakesleeana* method (A. Mehlich).

Fig. V

THE DISTRIBUTION OF SOIL ANALYSIS VALUES FOR 0-8" TOPSOIL SAMPLES FROM FOUR MAIN COFFEE DISTRICTS

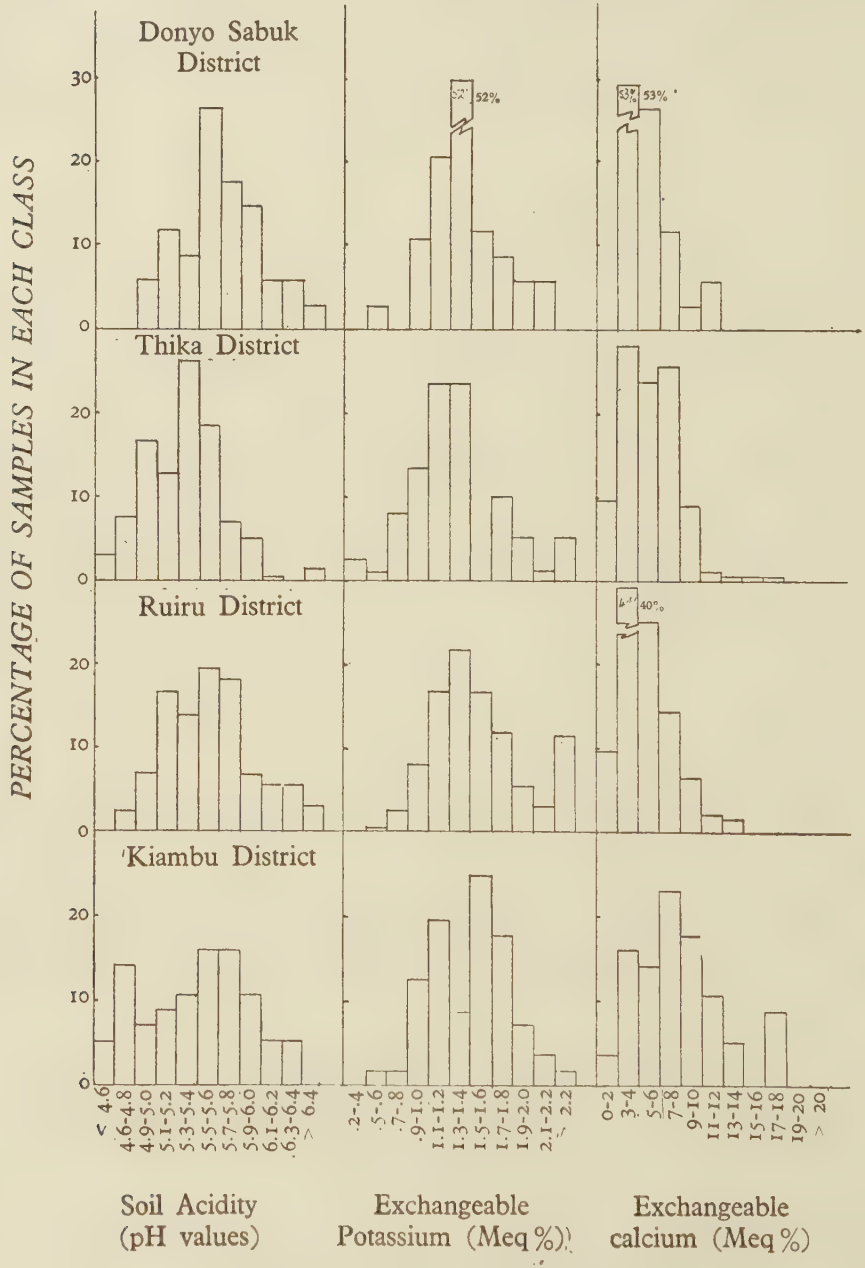


Fig. VI

THE DISTRIBUTION OF SOIL ANALYSIS VALUES FOR 0-8" TOPSOIL SAMPLES FROM FOUR MAIN COFFEE DISTRICTS

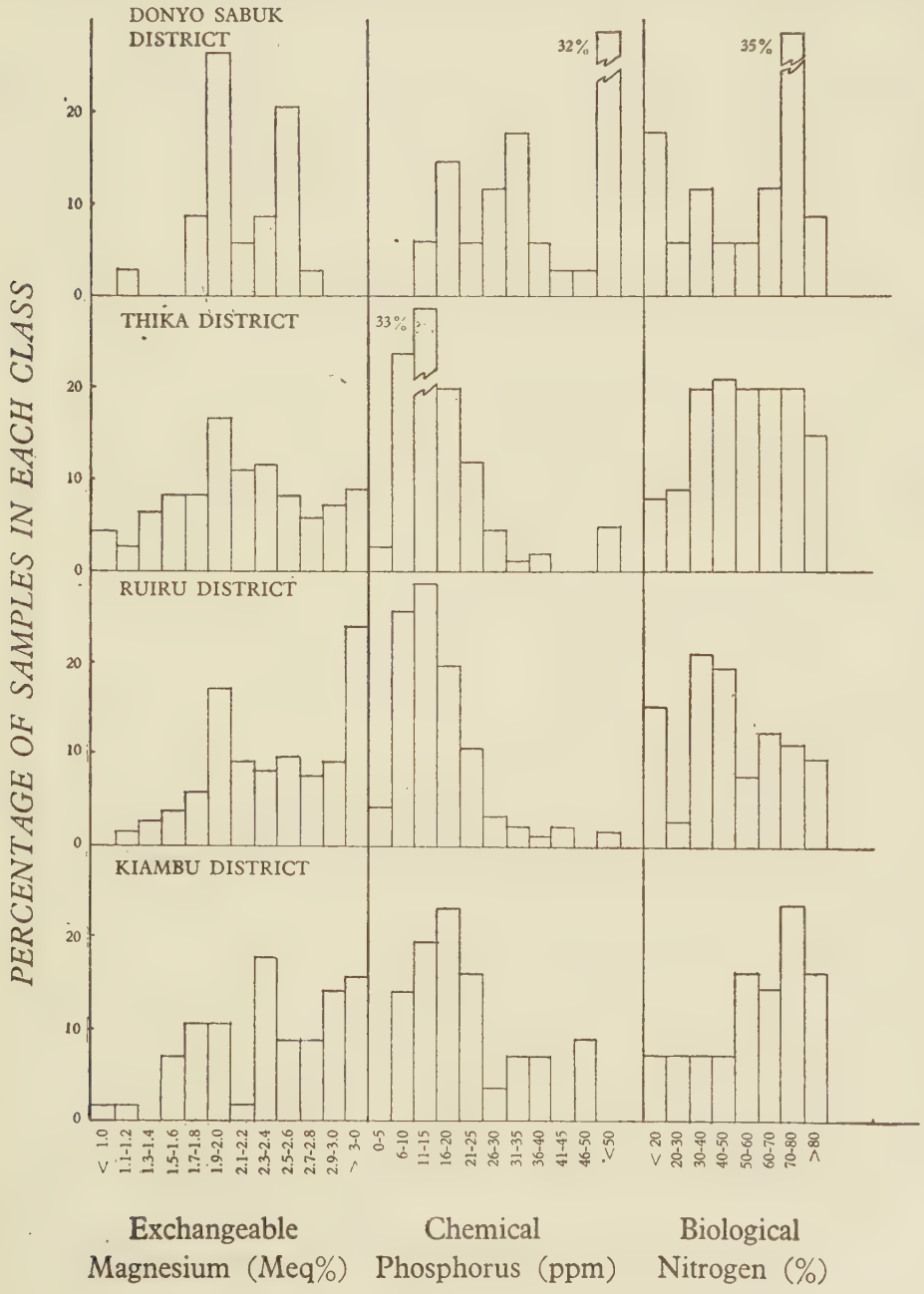


TABLE LXXVII

District mean values for chemical analyses of topsoil samples and for biological nitrogen analyses.

Analytical factor	*Kiambu (K)*		*Ruiru (R)*		*Thika (T)*		*Donyo Sabuk (DS)*	
	Mean	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
pH (acidity)	5.4	0.6	5.6	0.4	5.3	0.3	5.7	0.4
	K<* D.S.; T<** D.S. and R.							
Potassium (meq%)	1.49	0.374	1.58	0.462	1.36	0.435	1.42	0.355
	R>* T and D.S.							
Calcium (meq%)	7.6	4.6	5.1	2.6	5.7	2.7	5.2	2.3
	K>** R, D.S. and T.							
Magnesium (meq%)	2.46	0.607	2.52	0.612	2.18	0.624	2.43	0.554
	T<* K and R.							
Phosphorus (ppm.)	21	11.7	15	8.2	15	9.2	27	9.4
	D.S. and K>* R and T.							
Biological nitrogen	59	12	48	14	54	9	54	18
	K>** R.							

Notes: 1. Statistical significance between means is quoted as for example K>** R.
2. S.D. = Standard Deviation of a mean.

The mean value for the Kiambu and Thika Districts are similar and significantly lower than the Ruiru or Donyo Sabuk Districts. The pattern of distribution is similar for the Ruiru and Thika Districts, which are similar climatically, but is more spread out for the Kiambu District.

Potassium. Differences in the mean values and the distribution pattern between the Districts are small. This uniformity is probably the result of the general application of grass mulches in coffee.

Calcium. There is a marked difference between the relatively high mean value for the Kiambu District and the other District mean values. Similarly, the distribution is more spread out over a wide range of values for the Kiambu District.

Magnesium. The mean value for the Thika District is noticeably lower and coincides with the lower potassium mean. The distribution of the analytical values is very irregular and wide in the Kiambu, Ruiru and Thika Districts but different from the Donyo Sabuk District data. The mean ratio values for K: Mg are narrow i.e. 1:1.7; 1:1.6; 1:1.6; 1:1.7 for the Kiambu, Ruiru, Thika and Donyo Sabuk Districts respectively and they show very close agreement. These ratios are all considered to be narrow for a coffee soil.

Phosphorus. Donyo Sabuk closely followed by the Kiambu District have appreciably higher overall mean values. However, the most well defined difference between the Districts is the distribution over the range of grouped analytical values. This is similar, with the peak values low down on the scale, for the Kiambu, Ruiru and Thika Districts; the data for Donyo Sabuk are irregularly distributed and contain a large proportion of light soil phosphorus values. This is thought to be attributable to the regular application of cattle manure and, in more recent years, sisal waste as well as to a regular mulching policy on some plantations.

The distribution histograms are very similar in pattern for the Kikuyu dark red loam (Kiambu District) and red loam (Ruiru and Thika Districts) but show marked differences in some instances for the mixed soils in the Donyo Sabuk District.

COMPARATIVE CHEMICAL LEAF ANALYSIS

Leaf samples from coffee suspected of being unbalanced in its nutrition and/or exhibiting a deficiency syndrome (subject to the ability of current knowledge to distinguish), have been collected and analysed. Samples have always been carefully selected with regard to leaf age, cropping condition, weather conditions and the cultural level in the field; where a visible deficiency syndrome has been observed, comparable leaves which were outwardly green and healthy have also been collected at the same time. Differences in the analytical results given in Table LXXVIII therefore tend to bracket the level at which a visible syndrome is observed.

More analyses have been undertaken for nitrogen, phosphorus, potassium, calcium and magnesium than for the micronutrients; iron, manganese, boron and zinc. The most frequent problems which occur in both African and European areas may be summarised as:

(a) Low leaf nitrogen in both wet and dry seasons.

(b) Low leaf phosphorus values under dry topsoil conditions.

(c) Low magnesium values and/or a wide ratio of potassium to magnesium.

(d) Low leaf zinc values under dry topsoil conditions. Some typical results are presented in Table LXXVIII.

TABLE LXXVIII

Comparative leaf analysis results. (Content in leaf dry matter)

	Sample Reference		*% Nitrogen*	*% Phosphorus*
A.	*Nitrogen and Phosphorus or Phosphorus only.*			
1.	K7 variety	Old green leaf	1.283+	0.0753
	(Makuyu District)	Old yellowed leaf	1.065+	0.0445+
2.	Bearing coffee	4th leaf pair	0.887+	0.0468+
	(Meru District)	(yellow leaf)		
3.	Bearing coffee (Fort Hall District)	Green leaf-4th leaf pair	2.149	0.1502
		Yellow deficient leaf, 4th leaf pair	1.124+	0.0756
4.	Bearing coffee	Green leaf, 5th-8th leaf pairs	1.752	0.1734
	(Machakos District)			
		Yellow/red autumn leaf tints, 5th-8th leaf pair	0.959+	0.0742
5.	Bearing coffee	Old green leaf	—	0.1239
	(Embu area)	Old leaf, red autumn tints.	—	0.0302+
		Healthy—4th node	—	0.0705
		Healthy—12th node	—	0.1079
6.	SL 9 variety	Blue-green leaf; 4th node	—	0.0635+
	(Ruiru District)	leaves bent down and back; 12th node	—	0.0668+
7.	Bearing, old Multiple stem head.	4th leaf pair (no crop)	—	0 1157
	(Kiambu District)	9th leaf pair (crop)	—	0 0880
		13th leaf pair (crop)	—	0.0465+
	Bearing, young Multiple stem head (Light crop only)	2nd and 3rd leaf pair (no crop)	—	0.1199
		6th and 7th leaf pair (no crop)	—	0.1022
		9th and 10th leaf pair (crop)	—	0.1442
		15th and 16th leaf pair (crop)	—	0.0960

			% *Potassium*	% *Magnesium*	*K : Mg ratio*
B.	*Magnesium : Potassium*				
1.	Bearing coffee (Kiambu District)	Old leaves	3.55	0.19+	18.6:1+
2.	Bearing coffee (Baringo District)	Old leaves	2.25	0.10+	22.5:1+

			Zn(ppm.)
C.	*Zinc.*		
1.	Bearing coffee. (Donyo Sabuk District)	Green leaf, 1st leaf pair	20 8
		Zn Deficient leaf, (chlorotic) 1st leaf pair	4.6+
2.	Coffee just harvested (Donyo Sabuk District)	Green leaf, 1st leaf pair	35.9
		Zn deficient leaf, 1st leaf pair	10.9+
3.	Non-bearing coffee (Kitale District)	Green leaf, 1st leaf pair	21.0
		Zn deficient leaf, 1st leaf pair	10.0+
4.	Bearing coffee (Makuyu District)	†Zn Chelate injected (2 months) 1st leaf pair	13.4
		Control Zn deficient, 1st leaf pair	6 8+
		Zn chelate injected (3 months) 1st leaf pair	23 5
		(1) Zn deficient 1st leaf pair	8.9+

Notes: +Less than the provisional critical level. For the K:Mg ratio figures this is a ratio greater than 10:1
†Visibly zinc deficient trees ± zinc chelate injection.

For the nitrogen and phosphorus or phosphorus only analyses leaf samples were, with rare exceptions, collected under very dry topsoil conditions and in the presence of a heavy crop. The values obtained suggest that the requirement of a maturing crop exceeds uptake by the tree from the dry topsoil. It can be assumed that there is no absolute deficiency of available phosphorus in the soil because signs of visible shortage are often absent and, when they do occur, they disappear soon after the rains start, even when the tree is making rapid growth. Nitrogen is supplied by fertilizer application during the rains on most plantations, but is not yet in general use in African growing areas. In respect of phosphorus these results bear out the conclusions reached in the following section of this Report.

The examples of magnesium unbalance are typical of a condition which is widespread in many coffee areas, particularly where the practice of heavy mulching coincides with above-average annual rainfall (>50 or 60 inches), falling in well defined and often relatively short seasons.

The zinc values were found in leaf samples collected under dry soil conditions, except those from the Kitale area. In the latter there are parts where a definite visible deficiency syndrome often occurs during the wet months. This suggests an actual shortage in the soil, a condition which is exaggerated as the topsoil dries out.

The leaf samples collected in the Makuyu District were from untreated and treated trees (Zinc chelate pill injection by the Roach technique. NaZnE.D.T.A. pills made up and supplied by Fisons Chemicals (Export) Ltd., for experimental purposes). The injection, 1 pill for every 3″ of stem circumference, 6″ above ground level, controlled the condition: the visible leaf syndrome disappeared and the leaf zinc values increased substantially.

An experiment was carried out on the Station during the Long Rains, 1959, to examine the efficiency of the zinc chelate injection technique. The zinc content of the fully open terminal pair of leaves on bearing branches (Single stem pruned trees) was determined. Two trees were injected on 1.4.59 and two trees were left as controls. The leaf zinc values are shown in Table LXXIX.

TABLE LXXIX

Leaf zinc values—Zinc chelate injection into the stems 6″ above ground level

(ppm leaf Dry Matter)

Date of sampling	*Control*		*Zn chelate injected*	
	A	B	A	B
1.4 59	10	5	24	13
10 4 59	8	12	270	380
18 4 59	17	27	295	430
28 4 59	17	16	86	200
22 5 59	9	12	261	80
27.6.59	7	10	>270	175

Notes: A's and B's are replicate trees.

There is little doubt of the efficacy of the technique for introducing zinc into the coffee leaves which should prove to be of value in diagnostic work. But there was some indication of phytotoxicity in the leaves at the time of sampling on 18.4.59. Old mature green leaves exhibited discrete, dark, necrotic spots between the leaf veins; young, immature growth exhibited necrotic spots between the main lateral veins and death of the leaf tip. Occasional small tip leaves were killed completely. By the end of April the damage was noticeably less and on 22nd May there was no evidence of phytotoxic symptoms on the leaves at all.

A similar comparison was made on an experimental basis between iron chelate (NaFe E.D.T.A.) pills made up and supplied by Fisons Chemicals (Export) Limited) and ferrous sulphate pills. No visible iron deficiency syndrome was observed in the tree at the time of injection. The pills were injected in the same manner and at the same time as the zinc chelate pills but with rather different results, see Table LXXX.

TABLE LXXX

Leaf Iron Values—Iron Sulphate and Iron Chelate Injection into the stems, 6" above Ground Level

(ppm leaf dry matter)

Date	(1)	*FeS04 injected*	*Fe Chelate injected*
10 4 59	268(3)	389	251
18 4 59	165	244	167
28 4 59	192	194	164
22 5 59	122	122	137
27.6.59	132	186	193

Notes: 1. Values are means of three single tree replicates.

2. Injections were made on 1.4.59.

There is no marked effect of the iron chelate injection on leaf values, such as was found with the zinc chelate. It is impossible to say from a consideration of these figures that the iron chelate pills have had any effect at all; the ferrous sulphate pills might have brought about the higher mean values found in samples taken on 10.4.59 and 18.4.59 but the effect, if it is a true one, was not very persistent.

The apparent absence of any effect of iron chelate injection is surprising, particularly in view of the marked effect brought about by zinc chelate injection. The latter was expected to produce a greater degree of difference than the iron chelate injection, because the zinc content of coffee leaves is only 1/5th to 1/10th approximately that of iron under natural conditions.

In one coffee area on Mount Elgon symptoms which were rather puzzling initially have now been diagnosed tentatively as being due to a Boron toxicity. Under heavy shade (*Grevillea Robusta*) the symptoms developed are a coarse mottled chlorosis which encroaches irregularly from the distal leaf edges into tissue between the lateral veins and extends around the distal leaf edge. Patches of unshaded coffee show a similar leaf pattern, sometimes in rather younger leaves, except that the sunlight has burnt or scorched the chlorotic areas to a bronze-brown colour and the margin between the damaged and healthy tissue is much more clearly defined. Bifurcated leaves and one or two pairs of dwarf leaves occur and would seem to be related to the general unbalance. When analysed Boron contents of leaf samples have been very high, as shown in Table LXXXI. Samples were taken from Multiple stem trees.

TABLE LXXXI

Boron (and Calcium) content of coffee leaves believed to be suffering from toxicity symptoms.

(ppm leaf dry matter)

Leaf Sample	*Calcium ppm.*	*Boron ppm.*	*Ca:B ratio*
A. Unshaded coffee, non-bearing primaries			
No necrosis, 4th leaf pair.	18,000	124	145:1
Necrotic, 7th and 11th leaf pair	20,000	195	103:1
B1. Shaded coffee, bearing primaries			
No chlorosis, 1st mature leaf pair	15,800	54	292:1
Very small leaf, 3rd and 5th nodes	17,000	273	63:1
Large chloritic leaf, 6th and 7th nodes	19,000	290	69:1
B2. No chlorosis, 1st mature leaf pair	18,000	135	133:1
Old chlorotic leaves 14th-16th nodes	29,000	7,300	—ᵒ—97:1

The calcium values are considered normal, the boron values high and the ratio of Ca:B narrow, particularly in old leaves. Further samples are being collected at monthly intervals to confirm this condition and to obtain a picture of the change in leaf composition with season and crop.

Variations in leaf phosphorus levels with sampling time

During 1958 and 1959 visual leaf symptoms of phosphorus unbalance (deficiency) were observed in certain plots of unmulched coffee on this Station. These observations were confined to the extremely dry period during September and October in both years.

The symptoms were first observed in one block of coffee, in September 1958. Spray applications of 1% W/W monoammonium dihydrogen phosphate plus a wetting agent (Shell "Teepol") were made in October and November but, after two weeks of rain in the first half of November, leaf symptoms (autumn tints on old leaves) had disappeared. Nevertheless (as will be seen from the curves in Figure VII) the phosphate spray did raise the level of leaf phosphorus significantly. The sprays were repeated during the Long Rains 1959 but there was no significant increase in the level of leaf phosphorus following the second application. It is suggested that the low leaf phosphorus levels in September, October and early November are the result of dry topsoil conditions at the time.

Following the increase in leaf phosphorus during May, when the topsoil was moist and the rate of growth was decreasing rapidly, the levels fell again in June as the topsoil began to dry out.

The conclusion that topsoil moisture is a controlling factor in the phosphorus nutrition of the coffee tree on this soil (Kikuyu red loam coffee soil) is supported by the changes in leaf phosphorus level shown in Figure VIII. In this instance there was a maturing crop on the tree from April through to November. The soil moisture content in the top two feet of the soil profile was below the wilting percentage during September and October and was rewetted by the Short Rains during November and December. Highly significant changes with time are recorded between sampling dates, although the October leaf level (leaves from the new wood, non cropping zone) is not particularly low and does not approach the critical value which is tentatively placed at 0.06% (N.B. at 0.06%P in leaf dry matter or less, the phosphorus deficiency syndrome is apparent). The leaf phosphorus curves in Figure II (mulch and no mulch leaf analysis values) show a similar trend with time of sampling particularly the no-mulch control treatment.

It is tentatively concluded that the application of soluble phosphate sprays (e.g. diammonium phosphate) might overcome severe phosphorus shortage in the tree during the height of drought periods.

Fig VII

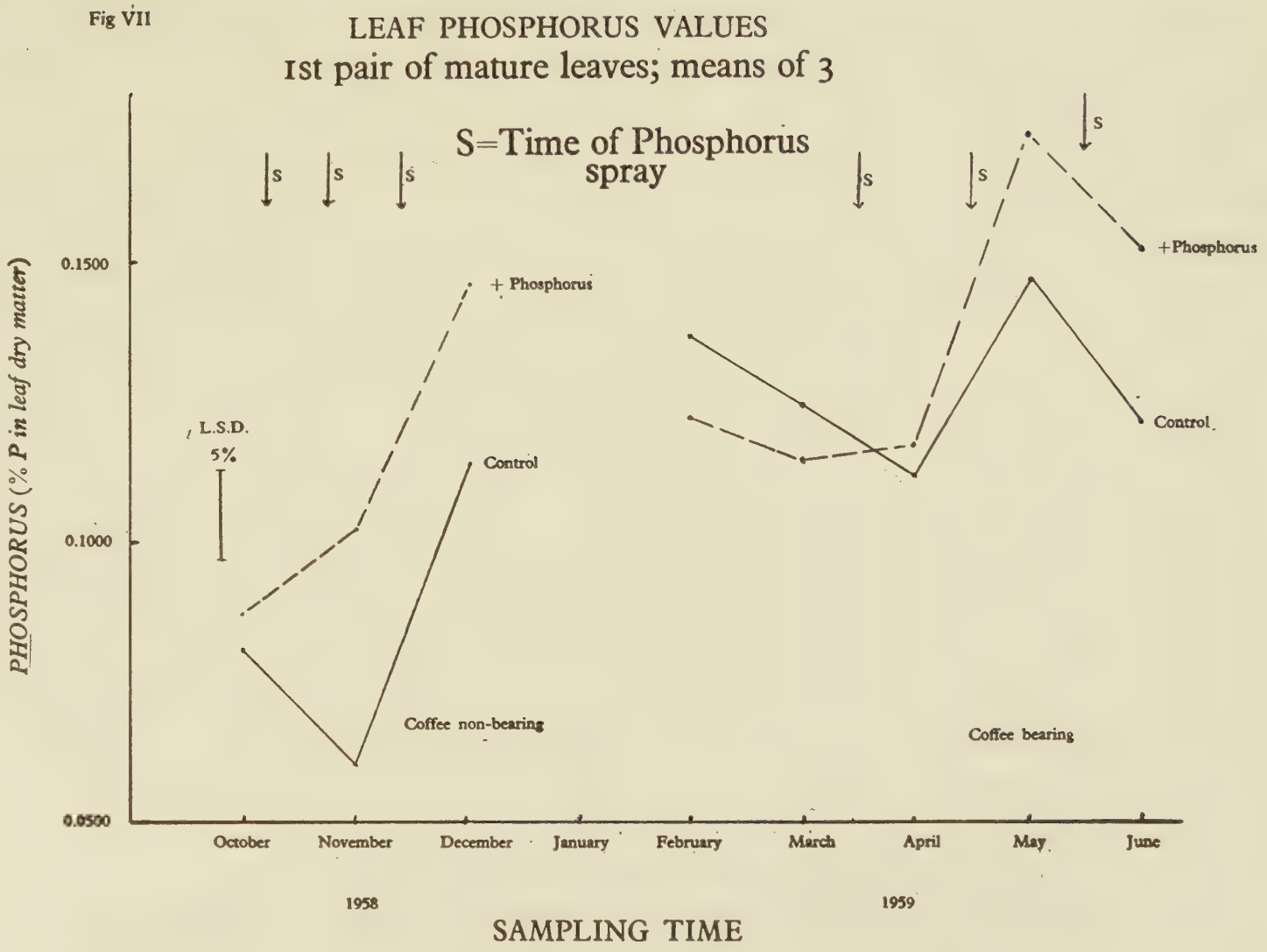
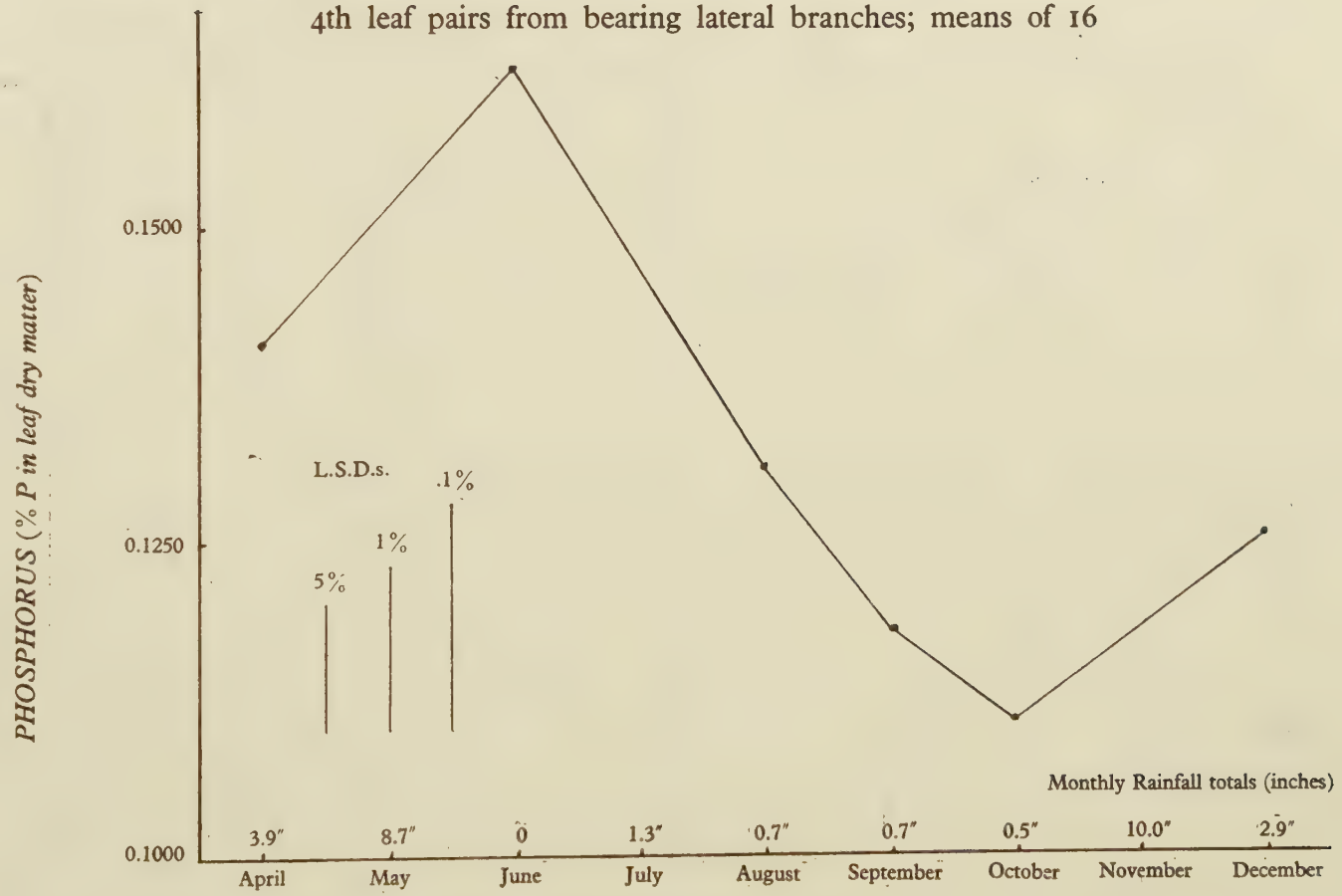

LEAF PHOSPHORUS VALUES
1st pair of mature leaves; means of 3
S=Time of Phosphorus spray
S
S
S
S
S
S
+Phosphorus
+ Phosphorus
Control
Control
L.S.D.
5%
Coffee non-bearing
Coffee bearing
PHOSPHORUS (% P in leaf dry matter)
0.1500
0.1000
0.0500
October
November
December
January
February
March
April
May
June
1958
1959
SAMPLING TIME

Fig. VIII

LEAF PHOSPHORUS VALUES, MANURIAL TRIAL II

4th leaf pairs from bearing lateral branches; means of 16



Field observations suggest that the presence of a heavy crop on the tree at a time of severe drought greatly accelerates the incidence of the visible deficiency syndrome. Symptoms have been confirmed in the field during February 1960 on coffee carrying an appreciable quantity of early crop. A more critical study of this problem is indicated from these preliminary results which agree with findings reported previously from Brazil, (7).

Spray Application of Plant Nutrients to Coffee

The application of nitrogen (as urea) and magnesium (as Epsom Salts) to the coffee leaf in sprays (Cocktail sprays) during the dry weather when uptake from the soil is probably limited by lack of available soil moisture, has become quite widespread throughout the industry. Reference to the graphs depicting plant nutrient levels for nitrogen and magnesium in Figures II & IV will assist in emphasising the most important times of the year in which to apply the sprays. Leaf nitrogen levels fall off very rapidly after the Long Rains have finished. (The crop is maturing on the tree between April and October–December) and leaf nitrogen sprays applied during late May to early November should have the most beneficial effect.

Leaf magnesium values fall off from April to July, particularly in the presence of a mulch, but are also relatively low throughout the dry season until the onset of the Short Rains in late October/early November. This period of low magnesium in the leaf is not so intense in the absence of a Napier Grass mulch. The critical period for the spray application of magnesium would appear to be from May through to October, with particular emphasis on the May to August period.

MICRONUTRIENT TRIALS

Mixed Chelate and fritted trace element (Glass) trial

The layout of this trial together with a description of the treatments is contained in a previous Report from this Station (1957/1958, page 55). The first crop yields were harvested during 1957 and results are summarised in Table LXXXII.

TABLE LXXXII

Summary of yields from the Chelate and F.T.E. trial

(cwt. clean coffee per acre).

Treatment	*Yield* (± *Cattle manure*)	*L.S.D's*
Control	6.6(14)	2 means of 14
Fritted trace elements (Glass)	6.8	1.2*; 1.5**.
Iron Lignin sulphonate	5.3	
Copper chelate	6.9	
Zinc chelate	7.5	
Manganese chelate	5.2	
Iron chelate	4.6	
Magnesium chelate†	5.0	
Iron magnesium chelate	6.3	
Plus Cattle manure *	6.04(63)	Not significant
No Cattle manure	6.12	

Notes: † Magnesium chelate applied at planting; equivalent annual application of magnesium as Epsom Salts thereafter.

* 1 ndebbe applied in the planting hole mixed with the topsoil.

No treatment has raised the yield above the control treatment significantly in this trial with the first crop. But the iron and magnesium chelate treatments have significantly reduced yields as have both the manganese chelate and the iron lignin sulphonate. The lack of response to cattle manure applied in the planting hole is most unexpected; there were no significant interactions between any of the treatments and cattle manure application. It is possible that the zinc chelate treatment will affect future yields positively; it is considered inadvisable therefore to draw any firm conclusions from the first year's crop results.

Iron chelate Trial

The third year's results from this trial were also the first crop from a new multiple stem pruning cycle. Yield results are summarised in Table LXXXIII.

TABLE LXXXIII

Mean Yields in the Iron Chelate Trial.

(Cwt. clean coffee per acre)

Treatment	*Yield* *1957/1958*	*1958/1959*	*1959/1960*	*Mean (3 seasons)*
Control	14.9(6)	2.5	4.3	7.2(18)
¼lb. NaFeEEDTA	15.9	3.9	1.6	7.2
½lb. NaFeEEDTA	19.5	2.8	2.8	8.3

None of the yield differences in this trial are statistically significant, although it is a coincidence that the higher rate of chelate application has produced an apparent yield increase of similar magnitude to the same rate of zinc chelate application (refer next section). The yield in the 1960/1961 season is expected to be a heavy one and the treatments will have a good opportunity to exert an effect.

Leaf analysis values for the season have not been completed at the time of writing.

Zinc Chelate Trial

The second year's results from this trial have been disappointing because of very low yields. Details of the trial layout and treatments were given in a previous Report.

TABLE LXXXIV

Mean Yields in the Zinc Chelate Trial

(Cwt. clean coffee per acre)

Treatment	*Yield* *1958/1959*	*1959/1960*	*Mean (2 seasons)*
Control	1.5(6)	1.5(6)	1.5(12)
¼lb. NaZnE.E.D.T.A.	2.2	1.2	1.7
½lb. NaZnE.E.D.T.A.	2.5	2.3	2.4

None of the yield differences are statistically significant and this trial will be discontinued. In the two-year aggregate yields there is a suggestion that zinc chelate may have increased yields; a similar indication was obtained from the chelate and F.T.E. trial summarised earlier in this report.

It is considered that study of the zinc nutrition of mature bearing coffee should be continued, in view of the low content of zinc which can be found in leaves at certain seasons and these trends towards a yield increase with zinc chelates.

Liquefied Seaweed Spray

A proprietary liquefied seaweed spray supplied by Messrs. Simpson and Whitelaw Ltd. of Nairobi was examined in a preliminary manner during late 1958 and 1959. This proprietary material is stated by the manufacturers to contain among other things, iron, manganese, molybdenum, copper and zinc together with magnesium. It was applied to mature, unshaded, single-stem pruned coffee on the Coffee Research Station at the recommended rate of 8 lb. per acre in November 1958, April and May 1959 and at a spray volume of $\frac{1}{2}$ pint per tree. There were two absolute field replications; leaf samples (1st mature pair) were collected from bearing lateral branches in May, July and August 1959 after the last spray application and were analysed spectrographically for the micronutrient levels. At no time was a visual difference detected in the colour or quantity of the foliage between the sprayed and the unsprayed trees during 1959. The results of leaf analyses are summarised in Table LXXXV.

TABLE LXXXV

Micronutrient Content of coffee leaves sprayed with a Liquefied Seaweed preparation.
(Mean ppm. in leaf dry matter, over 3 sampling periods)

Element	*Sprayed trees*	*Unsprayed trees*
Iron	149(6)	155
Manganese	143*	136
Zinc	9.9	8.7
Boron	75	71
Molybdenum	0.24	0.25

Note: *=means are significantly different.

From these results it will be seen that the leaf manganese content has been increased by the sprays. But levels of iron and manganese are considered to be adequate in the unsprayed, control, trees. The levels of zinc must be considered low however. No critical information is available to assess the molybdenum levels, although they do not differ between treatments. The mean values at each sampling time are summarised in Table LXXXVI.

TABLE LXXXVI

Micronutrient content of coffee leaves sprayed with a Liquefied Seaweed Preparation.
(Mean values, ppm. leaf Dry Matter per sampling.)

Element	*Sprayed trees*			*Unsprayed trees*		
	May	July	August	May	July	August
Iron	78(2)	179	198	72	157	236
Manganese	115	142	172	107	127	173
Zinc	11.0	8.6	10.1	9.7	8.8	7.6
Boron	40	92	94	37	71	104
Molybdenum	0.12	0.35	0.26	0.12	0.29	0.33

These results show that there has been an increase in iron, manganese, boron and molybdenum levels in the leaf (sprayed or not), with the cessation of very active growth getween May and July. Zinc values did not vary greatly and must be considered to be low at all times. Copper content of the leaf was not analysed because of routine copper fungicide application in May, a treatment which may also have raised leaf iron and manganese values through impurity.

It is suggested that further experiments might more suitably be carried out on coffee seedlings in the nursery prior to planting out in the field.

AMBER BEANS

'Amber' beans are a well-known feature of clean green coffee from some plantations in Kenya. Devonshire (II) has described amber beans as "smooth yellowish beans, cause unknown". During 1959 some attempt was made to determine the source of amber beans in the field. The preliminary results obtained showed that one important source was to be found in mature bearing coffee trees suffering from visual iron chlorosis; this was particularly the case where the condition was chronic because the coffee was growing on the site of an old native hut or cattle boma. More specifically it was shown that the source of amber beans was confined to apparently normal ripe cherry, taken from primaries on which the leaves showed iron chlorosis. Apparently similar cherry from the same tree, selected from normal healthy primaries, did not contain amber beans. Examples of the results obtained appear in Table LXXXVII.

TABLE LXXXVII

The proportion of amber beans in ripe cherry from iron deficient trees and primaries

	Sample	*Total number of beans*	*% of amber beans*
1.	Cherry from iron deficient trees	144	30
2.	Cherry from healthy trees.	170	0
3.	Cherry from iron deficient leaved primaries*	136	26
4.	Cherry from green leaved primaries*	114	0

Note. * Samples of ripe cherry from primaries on the same trees showing both symptoms. Equal number of cherries collected from both types of primary per tree.

Amber beans were separated from the green beans in a bulk sample of clean coffee derived from iron deficient coffee trees. A comparison of the roast and liquoring characteristics of the two types was made by Mr. C. R. Devonshire and his staff of the Coffee Marketing Board of Kenya.

At a given time and temperature of roasting, which was defined for the green coffee, it was found that amber beans were not roasted to the same degree. In a mixed coffee sample this would be one cause of unevenness in the roast. The liquors obtained with the roasts of green and amber beans were compared. Blind liquoring by three persons independently placed the samples in the same order, liquors from amber beans inferior to liquor from green beans; the general comments about the liquors from amber beans were "common, lacking in acidity". A more detailed report of this work has been published recently (12).

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2. Bremner, J. M., Determination of fixed ammonium in soil., *J. Agric. Sci.*, 1959, **52,** 147.
3. Robinson, J. B. D. and Chenery, E. M., *Emp. J. Exp. Agric.*, 1958, **26,** 259.
4. Ann. Rept. Coffee Research Services, 1958/59, page 37 (Table 42).
5. Ann. Rept. Coffee Research Services, 1956/57, page 57.
6. Robinson, J. B. D., Nitrogen Studies in a Coffee Soil, Part I, *J. Agric. Sci.* (In the press).
7. Medcalf, J. C., Lott, W. L., Tecter, P. B., and Quinn, L. R., *I.B.E.C. Res. Inst. Bull.* No. 6, 1955, page 13.
8. Robinson, J. B. D., Nitrogen Studies in a Coffee Soil, Part III. *J. Agric. Sci.* (In the press).
9. Jones, P. A., Robinson, J. B. D. and Wallis, J. A. N., Fertilizers, Manure and Mulch in Kenya Coffee, *Emp. J. Expt. Agric.* 1960 (In the press).
10. Robinson, J. B. D., Nitrogen Studies in a Coffee Soil. Part II. *J. Agric. Sci.* (In the press).
11. Devonshire, C. R., Explanation of the Coffee Report Form, *Bull. Coff. Bd. of Kenya*, 1956, **21,** 156.
12. Robinson, J. B. D., Kenya Coffee, 1960, **25,** 91.

PLANT PHYSIOLOGY

For the first time since the Coffee Team was formed in 1937 the combined functions of Physiologist and Pathologist were separated and the appointments to both posts were made during the year. The division of these studies and the consequent increase in staff allowed several new investigations to be undertaken; but as the reorganisation has been relatively recent only preliminary results are yet available from most of the experiments.

Growth Recording Trials

The rainfall for 1959 was nearer the average than in the preceding year, with the heaviest amounts in April and November. As always, there was a period of minimum growth in February and early March, but accelerated growth resulted from the first heavy fall in the latter half of March. This soon lessened, although both April and May had a good rain record, and there was no disturbance of the even decrease until a heavy fall in early November (a late start to the Short Rains) triggered off a sharp rise in growth rate, leading to a really high peak in December.

Multiple-stem trees appeared to respond to the stimulus of the rain more rapidly than single stem and, as always, shaded coffee registered more increase than unshaded.

It is somewhat surprising that irrigation did not produce a greater effect, considering that 1959 was a comparatively dry year and the equivalent of $23\frac{1}{2}''$ rain was applied to the irrigated plots without causing any deviation from the general growth curves.

At the Scott Agricultural Laboratories the picture was very similar, except that there was no marked response to the November rainfall, the growth showing only a small increase in November and December. In this respect the pattern was sharply in contrast to the growth at the Coffee Research Station where the unusually high peak in December was apparently caused by the good November Rains. Since there was similar rainfall in both months at the Scott Laboratories other factors must be responsible for the difference.

Multiple-stem trees achieved more growth than single-stem trees and stripped more than cropping trees, but this was only appreciable at the period of maximum growth.

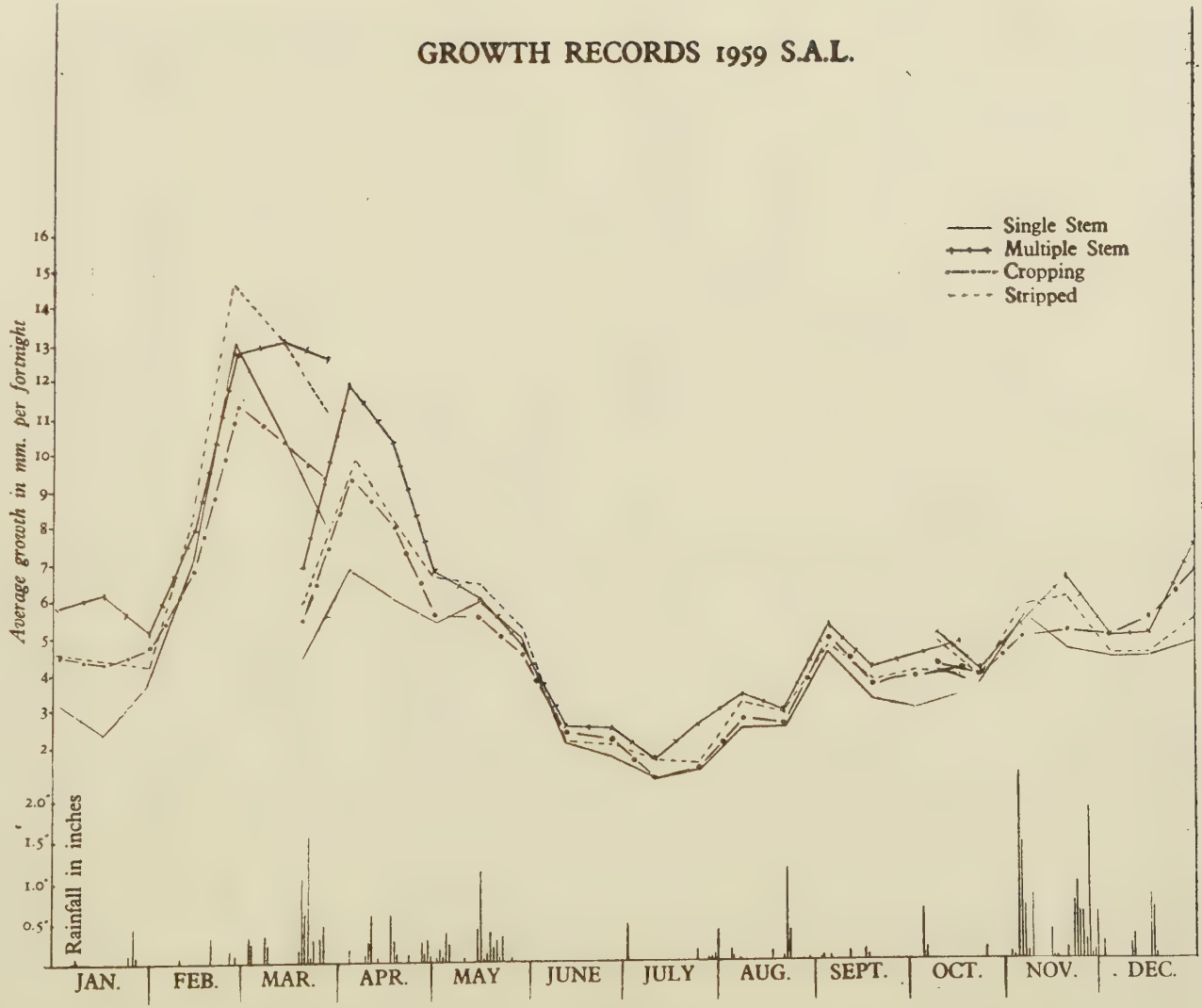
In marked contrast to the previous year the multiple-stem trees at the Coffee Research Station produced more crop than single-stem, but as in previous years, shade was more favourable than its absence while irrigation exerted little effect. The total crop was very small compared with that of 1958; hence the trend towards biennial bearing has not been prevented.

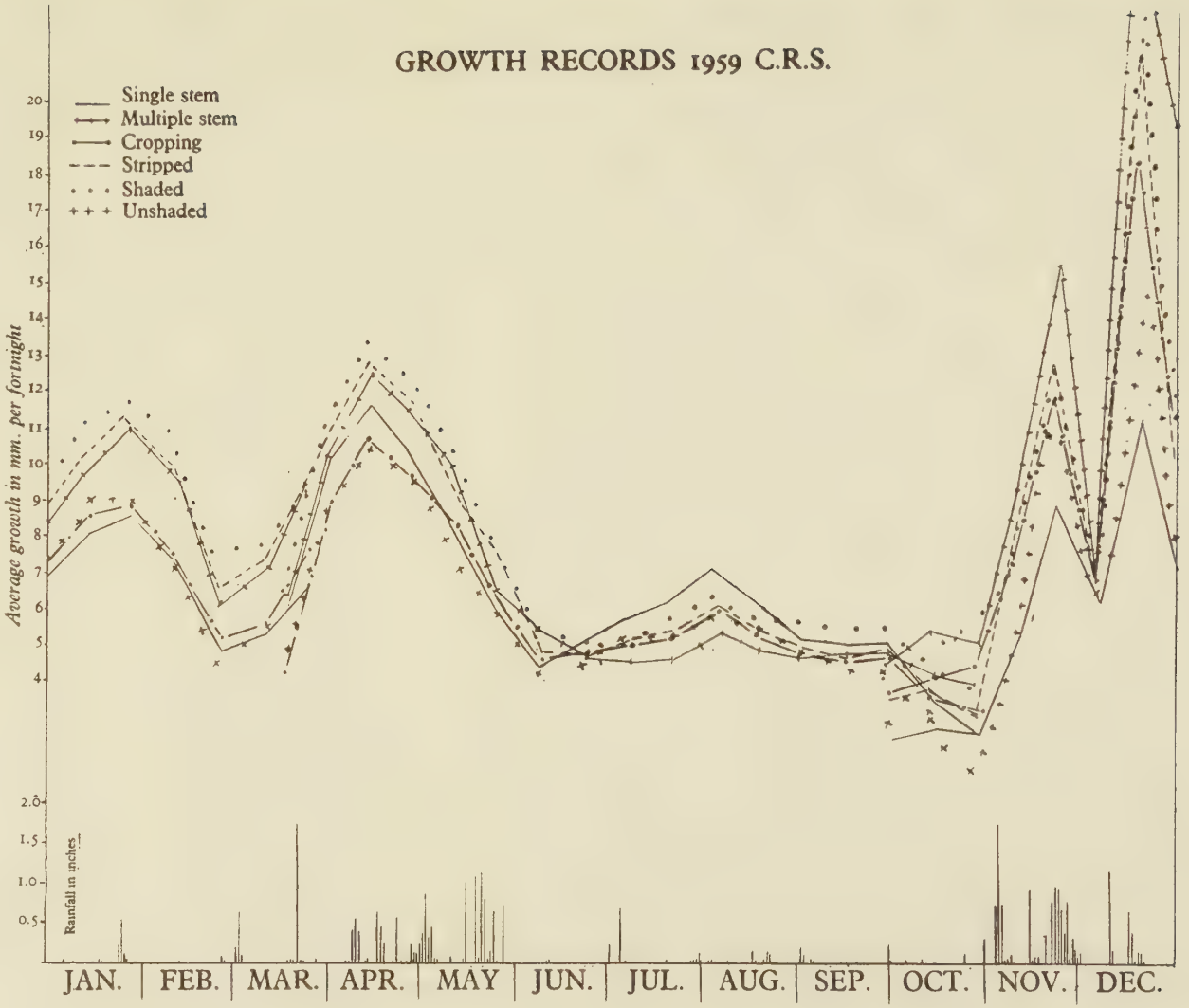
TABLE LXXXVIII

Growth Recording: Coffee Research Station, 1959

Yield corrected for cwt./acre of clean coffee

	Unshaded		*Shaded*		
	Unwatered	*Watered*	*Unwatered*	*Watered*	*Means*
Single	0.31	0.37	0.57	1.24	0.62
Multiple	4.23	3.62	6.08	8.07	5.50
Means	2.27	2.00	3.33	4.66	
	2.14		4.00		


GROWTH RECORDS 1959 S.A.L.
Single Stem
Multiple Stem
Cropping
Stripped
Average growth in mm. per fortnight
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
Rainfall in inches
2.0"
1.5"
1.0"
0.5"
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.


GROWTH RECORDS 1959 C.R.S.
Single stem
Multiple stem
Cropping
Stripped
Shaded
Unshaded
Average growth in mm. per fortnight
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
2.0
1.5
1.0
0.5
Rainfall in inches
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.

Carbohydrate Studies

(a) In conjunction with the Chemistry Laboratory, a study is being made of the levels of starch and mineral elements in various parts of the tree throughout the year. The experiment comprises three crop levels: No crop, "normal" cropping and overbearing. It is conducted on multiple-stem coffee. For every sampling each head is represented by three primaries: one from the topmost part of the tree, having no crop or visible flower buds, one representing the topmost half of the bearing primaries and one representing the lowermost half of the bearing primaries.

The first primary gives one leaf and one wood sample. The middle one, which is green and carries its first crop, is split into two parts: one with and one without crop or visible flower buds, thus giving two leaf and two wood samples, and one crop sample for two of the three treatments. The lowermost one of the primaries used for analysis is divided into three: one part with mature wood, one with green wood and carrying berries or visible flower buds, and one part without berries or visible flower buds; this primary gives three leaf and three wood samples and, for the cropping treatments, two crop samples. Each sample is analysed for starch while a mineral analysis is made in the leaf samples. In addition, starch measurement in roots will be undertaken. No work is done on sugars as Cooil (Paper prepared for distribution at Coffee Information Exchange, Kona, Hawaii, July 21-30, 1954) has found that seasonal variation on both reducing sugars and total sugars is of little importance.

(b) Preliminary investigations were directed towards the development of visual methods of starch measurement, for scientific as well as for practical (advisory) work in the field. In branches of multiple-stem coffee most of the starch is concentrated in the parenchymatous pith. After staining with iodine, the intensity of the developing blue colour can be estimated with great accuracy with the aid of a microscope with a low power magnification and a network graticule. For a given amount of starch in the pith the ratio of the size of the pith and the thickness of the surrounding wood cylinder (which carries starch only in the medullary rays) is of some importance for assessing the percentage of starch in the total dry weight, but comparison with chemical analysis showed a very satisfactory correlation between the two methods when used for single internodes up to a level of 2.5% of starch in dry matter. At this stage the tissue of the pith is dark blue and this intensity of colour does not change even when the amount of starch increases up to 6% (See Fig I).

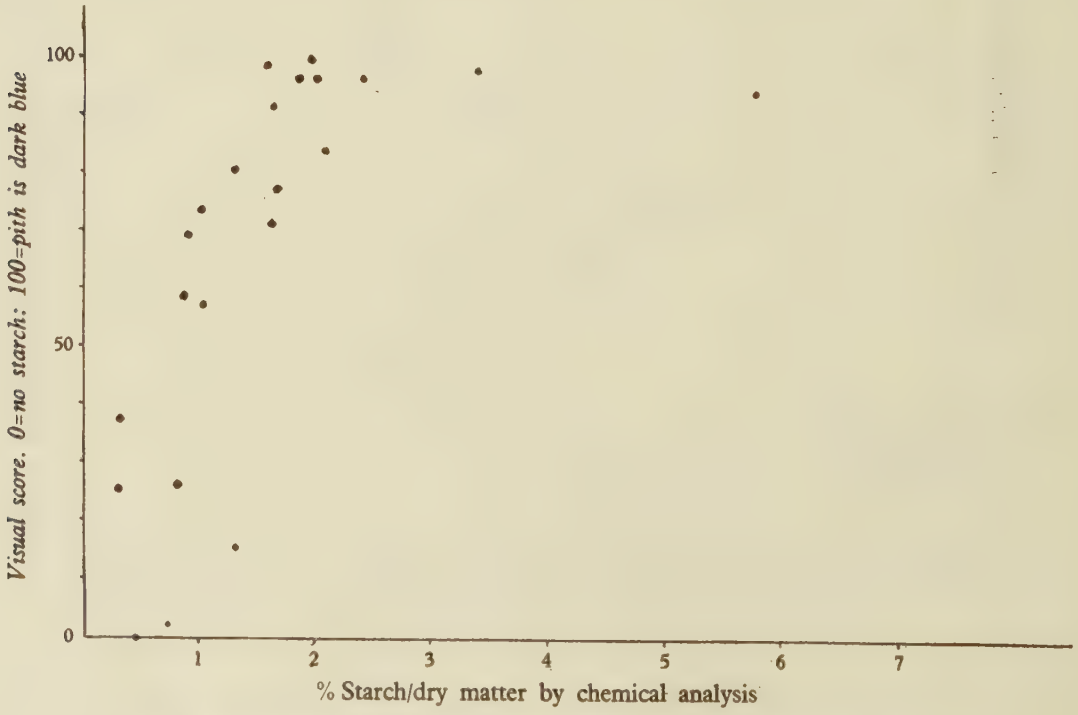


Fig. 1. Comparison of starch by evaluation by chemical analysis and by visual scoring.

It follows that visual scoring is inadequate for accurate investigations as it fails to make any distinction once a critical level is reached. The method might prove to be useful for field work once the seasonal variation in healthy coffee has been established; this is now under investigation.

Wassink's method (*Acta Botanica Neerlandica*, 2 (3), 1953, 327-348) of scoring starch in leaves in Helianthus, by extracting the chlorophyll and staining the starch with iodine, was investigated for coffee. The technique uses a constant light source, the amount of intercepted light being related to the quantity of starch present in the leaf. In coffee leaves, however, starch is not broken down and removed from the leaves at night, but is built up till it reaches very high levels. As a result staining with iodine often produces such a dark coloration of the leaves that all light is intercepted and no quantitative measurement is possible.

Water Relations

(a) Weatherley's method (*New Phytologist*, **49**, 1950, 21-97; Ibid. **50**, 1951, 36-51) of measuring water deficit of leaves was adapted to coffee. This method consists of punching discs out of leaves and measuring their fresh weight, their weight after floating on water and their dry weight. Details of the procedure vary with the plant under study. Sometimes an appreciable loss of dry matter occurs during floating which necessitates the use of paired samples, one being floated, one dried immediately after sampling. In coffee, the loss of dry matter after 24 hours floating is in the order of 0·5% of fresh weight and 1·5% of dry weight. In view of the accuracy of the method in general and of the difference between paired samples, which is of the same order of magnitude, and realising that the error is a systematic one acting always in the same direction, there is no reason to undertake the considerable amount of work involved in taking paired samples.

Size of disc, way of floating (abaxial or adaxial side up) and time of floating were studied, and results are reported in Fig. 2.

From Fig. 2 it follows that floating the discs with their abaxial side on the water causes an abnormal uptake of water, and the discs turn black by waterlogging. The same waterlogging occurs on the edges of the discs which are floated with their adaxial side down. This is the reason for the smaller discs absorbing more water than the larger ones. Because no period of floating shorter than 30 minutes was studied, there is no proof that the natural water deficit might not be replenished in less than half an hour. From the experimental data it follows that floating for one to two hours is adequate while it is desirable to standardise on one length of floating period and one size of disc.

Using the formulae

$$\text{Relative turgidity} = \frac{\text{Weight of water at sampling}}{\text{Weight of water after floating}} \times 100$$

one sees that at a given time the relative turgidity is the same all over the plant irrespective of the position of the leaf. Weatherley, working with cotton, found interesting relationships between relative turgidity, soil moisture and atmospheric conditions. Wormer and Ochs (Oléagineux 14 (10) 571-580, 1959) found that, apart from a small diurnal fluctuation, a serious water deficit in the leaves of oil palms and groundnuts only develops when the soil is near the permanent wilting point. Present knowledge on coffee indicates that this crop behaves likewise (Fig. 3), though the possibility of small fluctuations related to atmospheric conditions must not be neglected. Work on this problem is being continued.

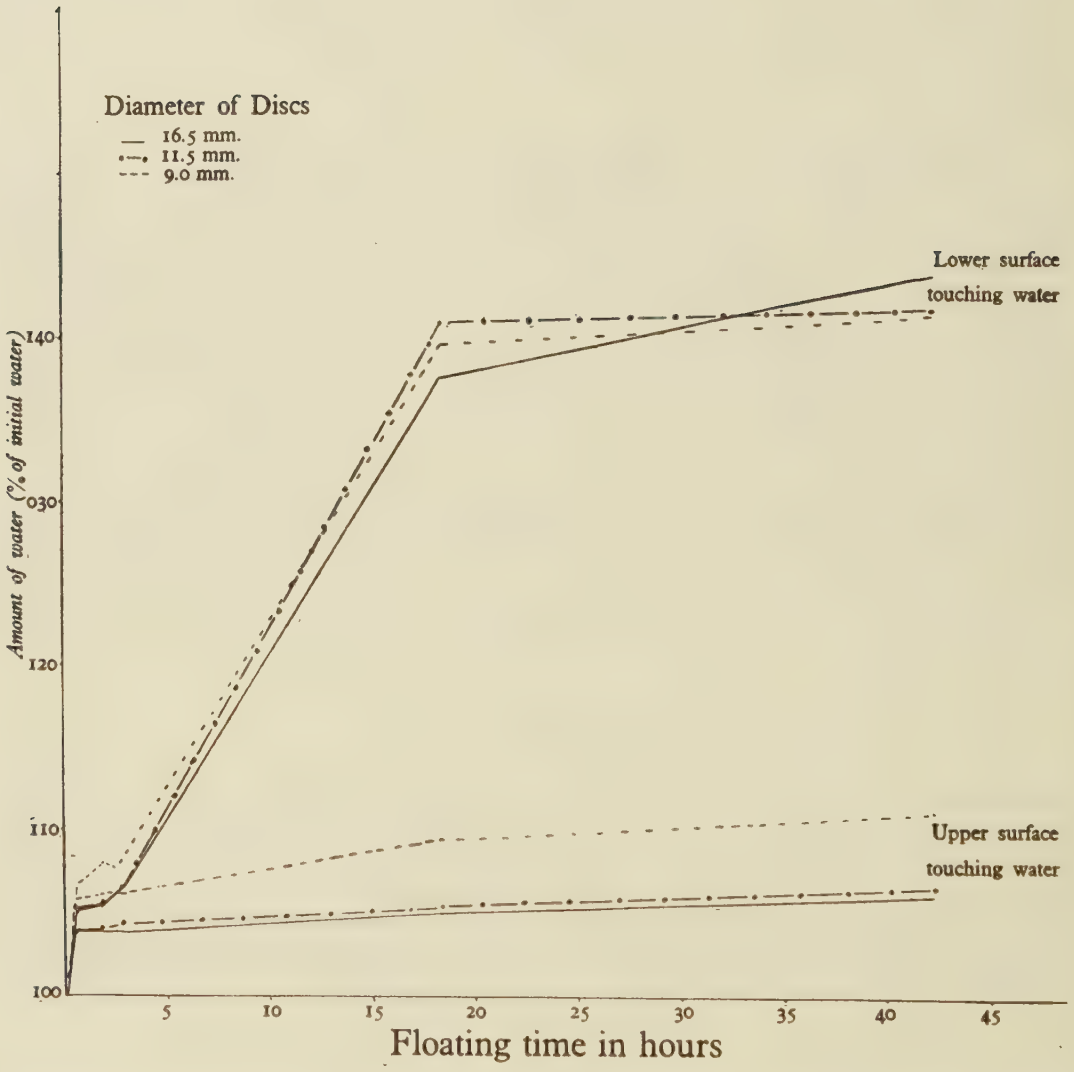


Fig. 2. Water uptake by discs of 9.0; 11.5 and 16.5 mm. diameter floated with the adaxial side or the abaxial side on the water.

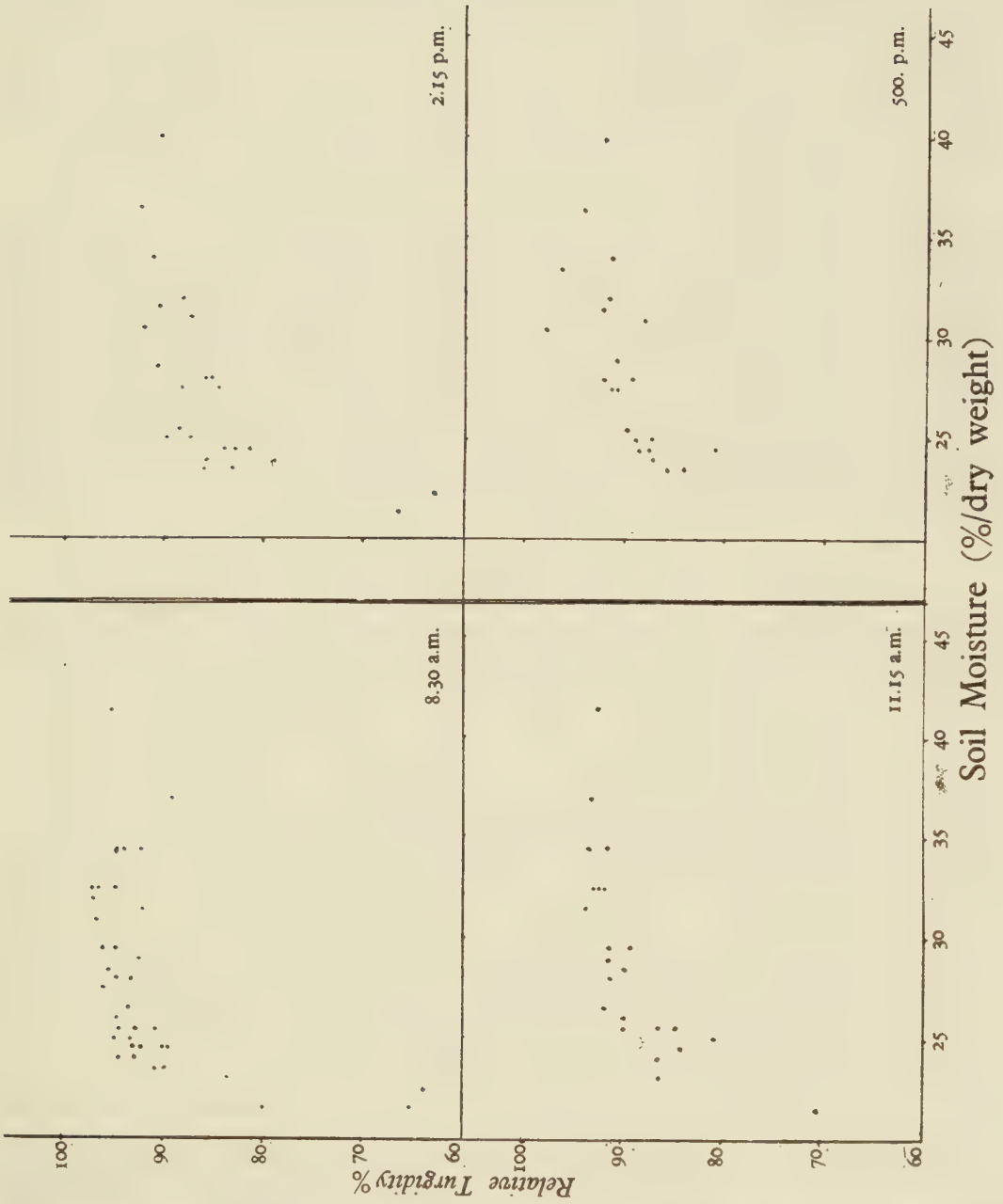


Fig. 3. Relative turgidity of coffee leaves at various hours of the day as a function of soil moisture pot experiment. Permanent wilting percentage = 24.14.

(b) Another line of investigation is the behaviour of the stomata in relation to the water balance of the tree. Molisch's infiltration method (*Zeitschs. Bot.* 4, 106-122, 1912) being used with mixtures of isopropyl-alcohol and water. A complication is that, according to Nutman's findings (*Ann. Bot. N.S.* I (4), 681-693, 1937) light intensity has an important influence in determining stomatal behaviour. This will be studied in more detail.

Leaf Fall

In the reports for the years 1954/1955 and 1956 by the Plant Pathologist/Physiologist (see Dep. of Agr. Colony and Protectorate of Kenya, Annual Report, 1955, Vol. II, pp. 81-100; Ibid, 1956, Vol. II, pp. 52-55) mention is made of spraying with hormones against premature leaf fall. This work was resumed, but it was felt that a more detailed investigation in the laboratory might be useful in order to facilitate field work.

Leaves cut back to a length of 20 mm. and kept in darkness show abscission (checked by exercising a constant force) after approximately eight days. This abscission can be delayed by dipping these "ex-plants" during a short time, e.g. 30 seconds, in a hormone solution to which a wetting agent is added. Variability between "ex-plants" taken from different trees or different branches of one and the same tree can be very pronounced. To overcome this difficulty "ex-plants" from one branch may be grouped, each receiving a different treatment, but adequate replication is necessary. Some results, obtained with ten groups of four "ex-plants" are represented in Table LXXXIX. Coffee leaves have no anatomically distinct abscission layer; abscission occurs by dissolution of the middle lamellae of an otherwise indistinguishable layer of cells. This might account for the more promising results of the very low concentrations. While work in the laboratory is proceeding on the lines described, the more promising treatments are being tested on young plants in pots. This will be followed by experiments on bearing plants.

TABLE LXXXIX

p.p.m.

			0	*5*	*10*	*25*	*50*	*250*	*500*	*1000*
	Expt.	7	8.9			12.2*		11.6	10.7	
N		8	6.4			6.6			7.6*	7.4*
A		9	10.7	12.2		12.2	13.9			
A		10	7.3	8.1	8.0	8.5				
	Exp.	7	5.6			7.5**		6.6	6.4	
2		8	5.6			7.0**			6.3*	6.0
4		9	8.8	12.0*		9.4	8.4			
D		10	6.2	7.5**	7.8***	7.9***				
2	Expt.	7	9.4			11.7*		9.8	8.9	
4		8	6.5			7.1			7.4	7.0
5		9	8.5	11.3*		7.8	7.4			
T		10	5.8	7.8**	8.2***	7.6**				

Table 2. Number of days between preparing the "ex-plant" and abscission under various treatments with 1-naphthyl-acetic acid, 2:4 dichlorophenoxy-acetic acid and 2:4:5 trichloro-phenoxy-acetic acid.

* difference with 0 ppm. significant at 0.05 level.
** „ „ „ „ 0.01 „
*** „ „ „ „ 0.001 „

The Action of Mulching on Root Systems

There are sound theoretical grounds for the contention that grass mulching, when practised for some years, will modify the root distribution of the tree within the top two feet of the profile. Trees in the Mulch and Soil Regeneration Trial at the Coffee Research Station have been mulched annually on one or both sides consistently every year for ten years.

When root systems of sample trees were exposed, by washing, no differences were found which could be ascribed to the presence or absence of mulch over a prolonged period. This result is certainly unexpected and may be due to various circumstances. Further study is required to clarify this problem.

"Hot and Cold" and "Crinkle Leaf" Disease

In conjunction with the Phytopathologist, observations were made on the anatomy of plants suffering from "Hot and Cold" disease and "Crinkle Leaf". Present work is mainly directed towards the study of the development of the symptoms in relation to environmental conditions. It is, however, obvious that exposure of the plants to certain meteorological conditions can explain much but not all of the appearance of the symptoms and that the condition of the plant has also some bearing on the problem.

PLANT PATHOLOGY

Stem-Pitting

A field survey of the condition was carried out. For the purposes of the survey three main types of symptoms were recognised, viz: bottling and/or furrowing at the basal part of the stem, furrowing associated particularly with the capping zone and no external symptoms at all but with gum pockets and pegs visible on peeling away the bark. All three symptoms apparently result from the same type of anatomical disturbance. Symptoms were found to be not necessarily associated with the basal part of the stem and furrowing at nodes higher up the tree was commonly found. Stem-pitting was found to be widespread in Kenya and occurred under all possible conditions of environment, cultivation and management. It has been found on numerous varieties of 'arabica' coffee and although varieties, such as K.7 and S.L.6, have often been noted with severe symptoms no definite differences in varietal susceptibility have yet been found. As a result of the survey it was concluded that while cultural treatments may affect the development of the symptoms they do not appear to initiate them. It was recognised that symptoms could start in the very young nursery plant where they consisted of islands of abnormally shaped and unlignified tissue in the xylem.

Many severely affected mature trees show no obvious loss of vigour or yield as a result of the condition, but the possible effects remain to be assessed. Under certain conditions very deformed seedlings have ben produced and older trees have suffered secondary invasion of micro-organisms through the furrows. Trees of over forty years of age have been shown to have had the condition at an early age and recovered without apparent ill effects. The severity of the condition in recent years, however, appears to be a new feature.

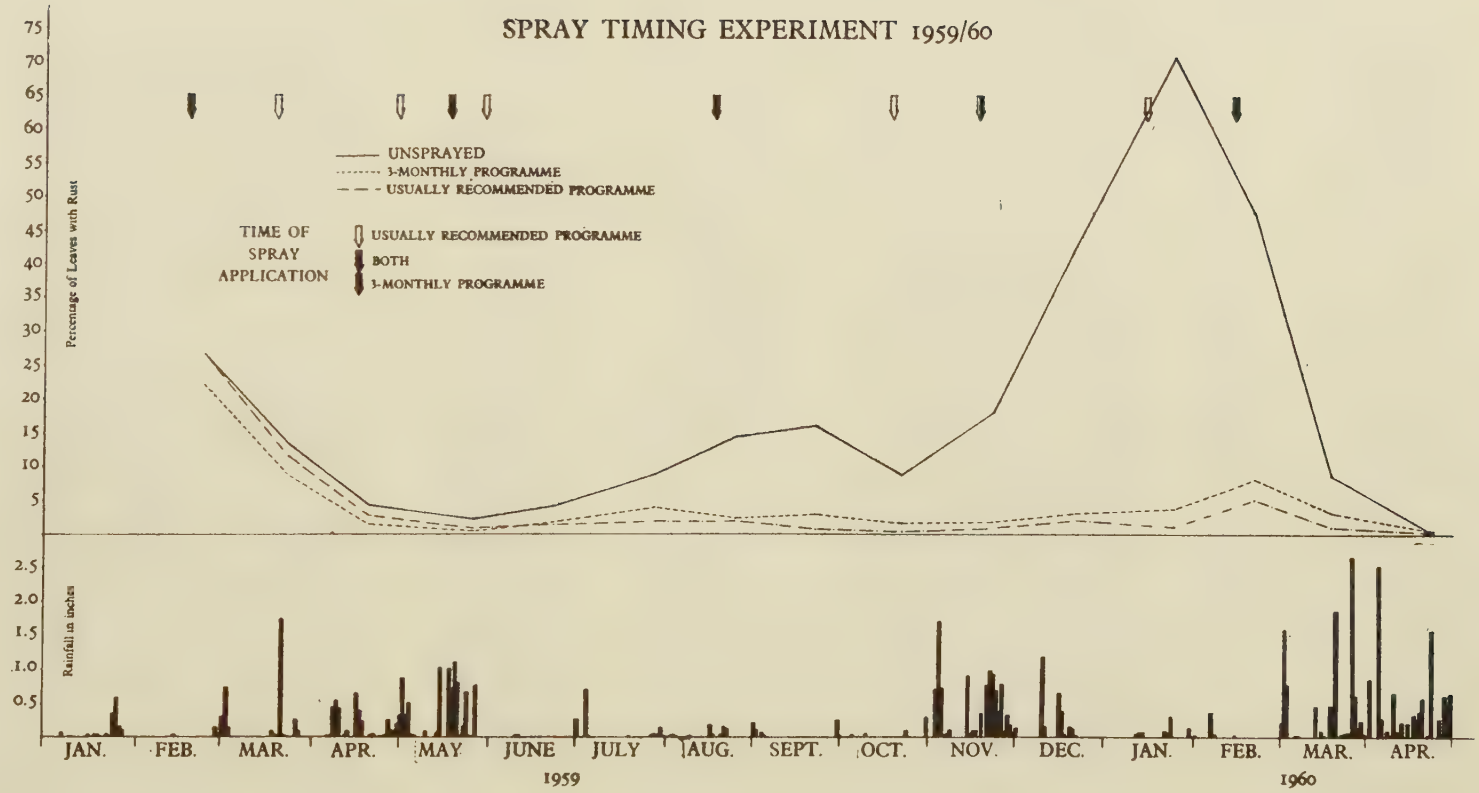
Leaf Rust

Routine screening for Rust Races has continued, particularly in relation to variety trials in different areas. Race I is confirmed in the following districts: North Nyanza, South Nyanza, Elgon Nyanza, Meru, Taita and Ithanga Hills. Numerous Rust collections from South Nyanza and other areas have again failed to reveal any further isolate of Race VII. The sole isolation of this Race in 1957 has therefore not been confirmed from its original site or elsewhere.

Fungicide Trials

The experiment commenced in October 1958 was designed to compare the efficiency of the following fungicides for Rust control: Burgundy, Perenox, Copper Oxychloride, Tricarbamix, Copper in Mineral Oil, Oleocuivre, and a colloidal copper formulation. Sprays were applied in October and early December in 1958 and in March and late April in 1959. On both sprayed and control plots Rust fell to a low level until May 1959. During the period July, August and September 1959 all the fungicides used gave good Rust control, but even in the control plots Rust infection was not heavy. Further sprays in October and November 1959 gave good Rust control during the Rust peak of January and February 1960. During the period, however, Burgundy and the 50% formulations of Copper oxide and oxychloride gave the best results.

A second experiment with Burgundy, Haft Vitigran, Fungex and copper dust was commenced in October 1959. Sprays were applied in October and November and in January 1960. The general level of Rust infection was again low in this experiment, but during January and February when infection was highest all treatments except the copper dust gave good control.


SPRAY TIMING EXPERIMENT 1959/60
Percentage of Leaves with Rust
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
UNSPRAYED
3-MONTHLY PROGRAMME
USUALLY RECOMMENDED PROGRAMME
TIME OF SPRAY APPLICATION
USUALLY RECOMMENDED PROGRAMME
BOTH
3-MONTHLY PROGRAMME
Rainfall in inches
2.5
2.0
1.5
1.0
0.5
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
1959
1960

Spray Timing Experiment

In this experiment spraying at 3-monthly intervals based on the May anti-leaf-fall spray (i.e., February, May, August, November) has given almost equivalent Rust control to the usually recommended spray programme (i.e., March, April, May, October, November and January) during 1959 and the first four months of 1960. The experiment has now been concluded because the layout was not susceptible to statistical analysis but good control of Rust has been achieved as shown in the accompanying graph which also shows the Rust picture at the Coffee Research Station, Ruiru, during this period in relation to the rainfall. It can be seen that both spraying régimes have controlled the heavy Rust attack during January and February of 1960. In the unsprayed plots the Rust level was as high as 75% of the leaves affected, while in the sprayed plots not more than 10% of the leaves were affected. The results serve to focus attention on the need for a critical assessment of the optimum spraying times.

Irrigation

Rust records are being kept on the irrigation trial to compare the effects of ground and overhead irrigation on the severity of infection.

Copper Toxicity

Copper sprays, applied at the usually recommended concentrations, have been found not to produce any ill effects even when applied at monthly intervals to run-off, over a period of more than a year. Coffee appears to be very resistant to direct damage from copper sprays. When copper sulphate is applied and the concentration of copper exceeds 1000 ppm brown necrotic spots appear on the leaves; below this concentration damage has so far been negligible. The possible cumulative effects of copper in the soil are not known, however.

Seedling Disease

An apparent fungal infection of coffee seedlings has been locally prevalent in some areas. A dead area occurs beneath the bark one to three inches above ground level; plants wilt and the leaves go brown or may show symptoms resembling "Hot and Cold". The lesion in the stem is usually well advanced before symptoms are noticed. Fungi of the genus *Fusarium* have been isolated from the lesions but are thought to be only weak parasites. It seems likely that only plants weakened by various adverse conditions are susceptible to this disease.

ENTOMOLOGY

General Pest Situation

The pest situation was very much as described in the 1958/59 Report. The dominant pest in most areas was Leaf Miner. Lace Bug and Antestia were next in importance. Of the various Leaf-eating caterpillars the Leaf Skeletonizer caused most damage. Other, more localised, outbreaks are mentioned below under the appropriate headings.

Research Programme

The pests having the highest priority in the research programme remain the Leaf Miner and the Tip Borer *Eucosma*. If the control measures devised for the Tip Borer continue to prove successful it is hoped that this pest can be dropped from the programme and more effort concentrated on the Leaf Miners at the end of 1960.

The long-term objectives of the insecticide work remain as described in the 1958/59 Report. They are:

(1) The increased use of pyrethrum sprays on foliage.
(2) The increased use of persistent insecticides for the indirect control of the various pests.

Leaf Miners. *Leucoptera* spp.

Damage by Leaf Miners *L. meyricki* Ghes. and *L. caffeina* Walk. was, as in previous years, widespread and severe, especially in the last six months of 1959. The shade-loving *L. caffeina* appears to be absent from the West Rift coffee areas despite the fact that much of the coffee there is heavily shaded.

The ovicidal effects of Pyrethrum were confirmed by work at the laboratories of the Pyrethrum Board of Kenya. Concentrations as low as 0.001% Pyrethrins are effective. During this work it was noticed that all the organo-phosphorus insecticides commonly used are ovicidal at normal field concentrations. This has been confirmed subsequently by field observations.

Little progress has been made in the search for a non-persistent insecticide which is safer than Parathion and effective at concentrations lower than those recommended for Diazinon. Only Murfotox 47 and Rogor appear to merit further trial. Diazinon, Parathion and Methyl Parathion are the insecticides currently used by Planters.

The study of Leaf Miner parasites was started during 1959. The first stage is the intensive collection from all coffee growing areas. Regular samples were received from five stations in the East Rift areas, three stations in the West Rift areas and from the Taita Hills. Species collected up to the end of March 1960 are tabulated below.

TABLE XC

Hymenoptera Bred from Leucoptera spp.

Name	HOST		STAGE ATTACKED		DISTRIBUTION		
	L. meyricki	*L. caffeina*	*ex-Larvae*	*ex-Pupae*	*East Rift*	*West Rift*	*Taita*
A. *Zagrammosoma sp.*	+	+	+		+	+	?
B. *Achrysocharella ritchiei*	+	+	+		+	+	+
C. *Apanteles bordagei*	+	+		+	+	+	+
D. *?Elasmus leucopterae*	+		+		+	+	+
E. *Pediobius coffeicola*	+	+		+	+	+	+
F. *Closteroceros africanus*	+	+	+		+	+	
G. *Parahormius sp.*	+	+		+	+	+	+
H. *Teleopterus violaceus*	+	+	+		+	+	+
I. *?Ageniaspis sp.*	+	+		+	+	+	
J. *Chrysocharis lepelleyi*	+	+	+		+	+	+
K. ?	+	+	+		+		
L. *?Cirrospilus sp.*	+		+		+		
M. *? Elasmus leucopterae*	+		+		+	+	+
N. *Tetrastychus sp.*	+		+		+	+	
O. ?	+		+		+		
P. ?	+		+		+		
Q. ?	+		+		+		
R. ?	+		+		+		
S. ?	+		+			+	
T. *Amblymerus sp.*		+	+		+		
U. *Cirrospilus cinctiventris*	+		+			+	+

Only one or two individuals of species of O, Q and R have been recovered. Other species in the Table unnamed or doubtfully named, have been sent to the British Museum. No egg parasites have been found. Collection was begun several months earlier in the East Rift areas and hence the larger number of species recorded than in the West Rift and Taita.

The next phase of this work, the study of the biology of the more important species, has now begun.

Since coffee is in flower only intermittently and the ground is for long periods free of flowering decotyledonous weeds, it seems likely that the normal food of Leaf Miner moths is not nectar but homopterous honeydew. In a laboratory experiment where adults were fed with either honey or mealybug honeydew, those fed with honey were shorter lived and produced less than half the eggs laid by those fed on honeydew.

Tip Borer. *Eucosma nereidopa* Meyr.

Using flower buds and small green berries as food a successful technique for the laboratory rearing of *Eucosma* was developed. The caterpillar changed its position two or three times during the larval period. This corresponds with field observations on its habits. At laboratory temperatures (mean approximately 21°C.) the following development periods were recorded: egg, 8 days; larva, 36 days; pupa, 21 days; pre-oviposition, 5 days. This makes a total of 70 days. Moth counts at Upper Kiambu suggest that, at the much lower temperatures prevailing in the field, the corresponding period is 120 days.

One of the indirect methods of control listed in the 1958/59 Report—the spraying of shade tree trunks—has proved so promising that work on other lines has been discontinued. At Kakindu Estate, which has had the worst attack, the shade trees have been sprayed four times in all and this has given sucker protection for three generations, i.e., one year. The sprays used were 2% D.D.T. at the beginning of the first moth emergence, $\frac{1}{2}$% D.D.T. at the emergence peak of the same generation, $\frac{1}{2}$% D.D.T at the beginning of the second emergence, and 1% D.D.T at the beginning of the third generation. The spray volume is approximately 6 gallons/acre for each application.

It was hoped that by using this indirect method of control that there would be virtually no interference with the larval parasites of *Eucosma* and this seems to have been borne out by events.

Leaf Skeletonizer. *Epiplema dohertyi* Warr.

The species continued to be the commonest leaf-eating caterpillar in most coffee growing areas. To put on record what is known of its biology a short article was prepared for publication in "Kenya Coffee".

Berry Moth. *Thliptoceras smaragdina* Butler

Very little damage was done by this pest during the 1959/60 season. Since research on its biology and control is in progress in Tanganyika no further spray trials were undertaken. Routine trapping of moths continued at Makuyu.

White Borer. *Anthores leuconotus* Pasc.

Recent work in Tanganyika (Tapley, R.G., in the press) has shown that banding the stumps of the coffee trees with $\frac{1}{2}$% Dieldrin is effective for at least 27 months on Kilimanjaro. To check that the rate of decay of the deposit under Kenya conditions is similar, samples of bark were sent to the Colonial Pesticides Research Unit, Arusha, for analysis. The average deposit after ten months was found to be 15.6 mg/sq. ft. This compares very well with a figure of 15.5 mg/sq.ft. after 11 months on Tanganyika trials.

The last general spray campaign in Makuyu was in October 1958. A survey was made in October 1959. 2,500 trees were examined from a total of ten estates. These estates all had a history of severe White Borer. No evidence of living larvae was discovered in any of the trees examined. It has now been agreed that no further campaigns are necessary. Planters have been advised to respray every two years. New plantings should be sprayed when the stumps are thick enough to attract ovipositing females, again one year after and after that every second year.

Several planters have reported that coccid-attending ants disappeared from their estates when Dieldrin spraying began and are still absent.

Borers in Machakos District

At a very early stage in its development, coffee on two isolated hill masses (Mbooni and Kilungu) have been attacked by a species of Cerambycid. This borer has not yet been identified but is closely related to *Anthores* and does very similar damage. It may be *Bixadus sierricola* White. The coffee on Mbooni has already been treated with Dieldrin since this is known to be effective against both *Bixadus* and *Anthores*.

Yellow-Headed Borer. *Dirphya nigricornis* Ol.

The confusion over the identity of this pest has now been settled. Up to 1956 the species which attacks coffee in the East Rift areas was listed as *Dirphya princeps* Jord. This species, now known as *Neonitocris princeps* (Jord.), attacks coffee in Uganda and possibly in the West Rift areas, but has never been recorded in the East Rift areas. From here and the Taita Hills intensive collection has revealed only *D. nigricornis*.

A short account of the biology of *D. nigricornis* was published in "Kenya Coffee" in October 1959. Since then some further observations on oviposition have been made. The female beetle stands astride a green shoot, about 3 inches from the tip, and raises a flap of green bark with her mandibles. The flap is hinged at the distal end and held down at the proximal end by uncut strands of tissue. Under this flap she inserts a single egg. The egg is elongate oval in shape, approximately 3.6 mm. long and 1.1 mm. wide at its largest diameter. It is brown in colour. Hatching took place after 14-19 days in the laboratory.

Antestia. *Antestiopsis lineaticollis* Stoal

Antestia attacks were not outstandingly severe in the East Rift areas. This appeared partly to be due to frequent sprays against Leaf Miner and partly to a high percentage of nymphal parasitism by the Braconid *Aridelus coffeae* Brues.

Antestia do not normally feed on mature coffee beans. This is presumably because the parchment is too tough for the mouthparts to penetrate. If, however, the parchment is stripped off and the dry bean is soaked for about four days in water it is readily accepted as food by the bug. Beans are a much more convenient food material than field-collected berries when maintaining a laboratory culture. Work was therefore begun on devising the most suitable cage for use in conjunction with soaked bean food.

Work on the two-phase method of Antestia control was completed and has been written up for publication. Final recommendations are the use of either a 0.006% Pyrethrins spray or a 0.3% Pyrethrins dust as a foliage treatment. These ensure an adequate knockdown of Antestia. To prevent paralysed bugs recovering and reinfesting the tree the stump should be dusted with either 5% D.D.T. dust or 0.5% Dieldrin dust. This control method was used commercially on about one thousand acres of coffee in the Kisii Highlands and satisfactory results were reported by the local Agricultural Officer.

Attempts to breed the Tachinid parasite *Bogosia minor* Vill., which is an important parasite of the Kisii form of *A. lineaticollis*, on the Ruiru form of the bug failed. The parasite went through a complete generation but only produced sterile eggs.

Lace Bug. *Habrochila ghesquierei* Schout.

The Lace Bug extended its range in 1959 as far as Embu and parts of the Nyeri district. Prompt spraying may have temporarily eradicated it in Embu. It has not yet been reported from Meru or Machakos.

Following reports from Uganda that the length of the egg stage is very variable this point is being re-investigated in the field at Ruiru since it has an important bearing on the timing of control measures.

Thrips. *Diarthrothrips coffeae* Will.

Thrips attacks, though rarely bad enough to justify spraying, were unusually severe towards the end of 1959 but generally negligible during the "Thrips season" of February-March 1960.

Counts on mulched and unmulched plots on the General Culture and Mulch Trials at the Coffee Research Station have shown that mulching reduced the Thrips population on the leaves by at least 40%-50%. There has not been a severe Thrips outbreak in the main East Rift coffee area since 1949. Up to this date they occurred roughly every four years. It seems likely therefore that the general changes in cultural practices (of which mulching is one of the most important) that have come into use in the last ten years have greatly reduced the potential seriousness of Thrips as a coffee pest.

The soil treatments with Aldrin and Dieldrin described in the 1958/59 Report gave significant control for approximately six months.

Star Scale. *Asterolecanium coffeae* Newst.

Work continued with Tar Oil applications to the bark. In a replicated experiment using 10%, 5%, 2.5% and 1.25% it was shown that the critical concentration lies between 2.5%, which is almost useless and 5%, which gives a very high percentage kill of the eggs. Previous failures with 5% Tar Oil appear to have been due to the condition of the bark at the time of application. If the bark is very dry it absorbs a large volume of the insecticide and excellent control is obtained. If, however, the bark is damp, very little is absorbed and the spray is virtually useless.

White Waxy Scale. *Ceroplastes brevicauda* Hall

Insecticide trials against this pest have proved unsatisfactory, chiefly due to the difficulty of deciding whether or not the Scale is dead. A study of its biology has been started to acquire the necessary basic information. There appear to be only two generations a year. Egg-laying coincides with periods of maximum extension growth in the coffee.

Ant Control

The control of coccid-attending ants, especially *Pheidole punctulata* Meyr., on mature coffee continues to be achieved with Dieldrin or Chlordane bands on the trunk. This is a very tedious procedure on coffee seedlings either in the nursery or during their first years in the field. Two other methods are now being tried:

(1) Overall sprays with Dieldrin. Different amounts of the 18% liquid in a standard volume of water have been sprayed uniformly over the soil in the hope of eliminating ants completely from the plot.

(2) The stems of young plants have been dusted with 2½% Aldrin dust. Using a small sack as an applicator one labourer can do about an acre an hour. 2 lb. of dust is sufficient for 500 trees.

The effective persistence of these treatments is now being investigated.

Mites

A Tarsonemid mite, probably *Hemitarsonemus latus* (Banks) has been noted a few times during the year. The damage resembles, but is apparently distinct from the "Crinkle Leaf" condition.

Tetranychid mites have been rather more noticeable than usual. There are some indications that this is associated with frequent Parathion sprays.

RESEARCH ON COFFEE PROCESSING

Mr. McCloy, who had been studying artificial drying and its effect upon the quality of coffee from 1956 to 1959, resigned his post with E.A.I.R.O. in March 1959 and the research work on coffee processing was continued by Mr. C. L. Gough at the Coffee Research Station.

A programme of investigation into the use of Ventilated Storage Bins was carried out at Kituamba Estate, Kiambu, by kind permission of Mr. T. K. Twist.

Tests were undertaken to assess the advantages of ventilation, by comparison with no ventilation, when coffee in the skin dry state has to be stored in depth in bins of 1½ tons capacity.

A series of tests was carried out with coffee which had been over-dried in the sun, to discover to what extent moisture could be restored to the coffee when ventilated during periods of high humidity. Conversely with under-dry coffee to ascertain the amount of moisture which could be extracted by ventilating during period of low humidity.

One skin-drying test was carried out in a 1½-ton bin fitted with a small electric heater, installed immediately below the fan. Depth of coffee for this test was five inches.

Similar tests were undertaken in the bin, with the electric heater installed, to investigate its possibilities of completing the drying of coffee in the black stage after five days' exposure to light on drying tables. The results of these tests indicate that the method has promising possibilities; a further series of tests is proposed in order to confirm the evidence already obtained.

A programme of investigation into the cause of the "onion flavour" taint in Kenya coffee is now in progress. The laboratory work for this investigation is being carried out by Mr. A. E. Wooton of the E.A.I.R.O.

The results so far obtained indicate a correlation between the production of propionic acid during fermentation and the "onion flavour" taint. It appears that the incidence and severity of the taint can be reduced by hastening the pre-washing and curtailing fermentation.

The majority of the worst cases of the taint, reported during the past season, were from Co-operative Society factories in the Embu district, where it is the practice to use abnormally long pre-washing channels and fermentation is continued for more than eighty hours.

COFFEE GROWING IN AFRICAN AREAS

During 1959/60 coffee development in the African Areas continued to gather momentum, as was envisaged in the Swynnerton Plan. African coffee production now constitutes about 20% of the Kenya crop and is valued at approximately £2,000,000. Despite adverse climatic conditions in Central Province and the greatly increased level of production quality standards were generally maintained in most Districts. The increase in African Coffee acreage is at present about 6,000 acres a year, about two thirds of this planting being in Central Province.

Considerable technological progress was made with the introduction of improved coffee drying technique and better pest and disease control methods. As a result of experimental work on African coffee shambas at Kisii (South Nyanza District) a new and highly efficient method of controlling Antestia was perfected. Spraying machinery experiments were also conducted in Meru District with a comprehensive range of equipment. Although these investigations proved to be far from conclusive, some important information was obtained anent the organisation and cost of coffee spraying in African areas. Detailed recommendations on the use of fertilizers were also prepared and resulted in considerable quantities of nitrogenous fertilizers being applied in some Districts. The use of Epsom salts and urea, incorporated with some of the anti-hemileia copper sprays, has also become standard practice in Central Province.

Factory Plans

Factory plans especially suitable for use in the African Coffee areas were prepared by the Ministry of Works, in close collaboration with Agricultural Department officers. These plans are now available to all Coffee Co-operative Societies at a price of 25 shillings.

Coffee Variety Trials

In 1959 a new series of *Coffee arabica* variety trials was planted in the Meru, Marsabit, Baringo and Laitokitok districts; the Rust Exposure trials in Meru, Central Nyanza and South Nyanza districts were also extended. Exploratory trials with *Coffee excelsa* were also planted below 3,500 ft. in the Embu district.

During the year the first crop was picked from the Indian varieties S.288, S.333 and S.795 planted in the Rust Exposure trials in 1956. All three varieties have continued to show immunity to Race I and Race II of the Leaf Rust disease, *Hemileia vastatrix*. If the liquoring quality and yields produced are satisfactory, they should prove invaluable in the Race I endemic areas of the Nyanza and Central Provinces.

The level of crop in Nyanza is now becoming clearly established. At the Kisii Farm variety trial (altitude 5,600 ft.) the highest yielding variety (S.L.28) has averaged only 5.81 cwt. of clean coffee per acre during the years 1953-1958; this compares with an average yield of 16.81 cwt. by the same variety at the Meru seed farm (altitude 5,500 ft.), Central Province, for the years 1954-1958. At Shikusa, North Nyanza district, the level of cropping has also been disappointing; the best variety in this trial was S.L.34, with a crop average of only 4.31 cwt. of clean coffee per acre for the years 1957 and 1958. Levels of yield were higher at Keumbu (altitude 6,200 ft.) in South Nyanza district, where the variety Kapretwa Series "A" produced a crop equivalent to 11.44 cwt. of clean coffee. It is now evident that yields in the region of 10 cwt. of clean coffee per acre can only be obtained in Nyanza Province at altitudes of around 6,000 ft. where Leaf Rust is not a serious debilitating factor.

In the Chemoge variety trial (altitude 6,700 ft.) in Elgon Nyanza district, Elgon Dieback has attacked all the varieties in the trial with great severity. Although the permanent shade trees are not yet providing an effective shade canopy the prospects for coffee development in this area must now be considered poor.

The experimental plot of *Coffea excelsa* planted in 1957 at Ishiara (altitude 2,900 ft.), Embu district, produced a first small crop in 1959. Quality samples were prepared and sent to Nairobi, where favourable comments were obtained from the coffee trade regarding both quality and market value.

At Busia in Elgon Nyanza district, the large *Coffea canephora* (Robusta) trial is now well established and it is anticipated that the first crop will be picked during 1960.

Advisory Work

Frequent visits were made by Mr. Hanger, Agricultural Officer (Research), to all the main African coffee growing districts and to the Marsabit, Nandi, Kitui, Baringo and Teita Districts. Members of the Coffee Research Services also made numerous visits to districts to investigate specific problems which were referred to them.

RUKERA DEMONSTRATION FARM

Development

There was no expenditure on capital improvements, in the form of buildings or machinery, during the year.

Land development at the top end of the estate was continued: 7½ acres were planted with S.L.34 seedlings in April. Although rainfall in April and May was sporadic and conditions were generally unfavourable for establishing seedlings, the choice of planting time was fortunate and a very high percentage of plants survived. An adjacent area of grass ley was ploughed and prepared for Napier grass in order to augment the supply of mulch grass which will be required for the new plot of coffee. The fringes of the latter were prepared for planting in April 1960. With the planting of these areas at the end of March the programme for opening up new areas for coffee has been completed.

Farm development of land and buildings has extended over a period of ten years. Now that this phase is past the next stage of improvement which is planned, is a programme for replanting all coffee plots with better varieties on a contour system, during the course of twelve to fifteen years. Thus five to six acres will be planted annually and, in order to minimise the period out of production, the procedure to be adopted will be as follows. Harvest of crop on the scheduled plot would be curtailed and the trees uprooted immediately. There would then be time to prepare for planting during the succeeding Long Rains. The first block scheduled for this treatment, however, was uprooted a year early, after the 1958/9 crop, as the trees were due to bear a negligible crop in their last year. Meanwhile the area has been surveyed and prepared for planting in April 1960.

1959/60 Crop

Rainfall: 1.1.59 to 31.12.59	32.78
Acreage in production	83.28
Clean coffee (tons)	25.65
Average per acre (cwt.)	6.16
Mbuni (lb.)	6,635

Classification	*lb.*	*Percentage*
Class 3	19,489	36.33
4	901	1.68
5	10,748	20.03
6	6,503	12.12
7	2,784	5.19
8	22	0.04
9	5,480	10.21
10	6,178	11.51
11	1,068	1.99
12	482	0.90

5,853 lb. of parchment were prepared as coffee seed from clonal blocks of S.L.28 and S.L.34. A clean coffee allowance for this has been added to the total weight of crop shown above.

The average basic scale price of the crop was 98.56 cents per pound calculated on the revised scale (99.88 cents per pound on the old scale.)

The Estate's entry was awarded second prize in the 'Grade A' class at the R.A.S.K. show in October.

Other Enterprises

During the year 9,187 lb. of Washington Navel oranges were picked from the two acres of trees, realising an average price of eight cents per pound. This is a very poor financial return and, as the project showed a substantial loss on the year, the future of this project is subject to early review.

The process of improving the standard of the dairy herd was continued; 12 cows and heifers were culled and sold and two in-calf heifers were purchased. The policy aims at reducing the number in the herd while raising milk yields to maintain output.

Farm Accounts

A primary function of the farm is the maintenance of Cost Accounts in a manner which will allow a detailed and valid assessment of all farm operations. When the objectives of the Demonstration Farm were originally defined it was considered that analyses of operation costs, obtained with accuracy from an independent and impartial source, would provide invaluable information whereby those interested and able to do so could compare the basic economic features with their own figures.

Much of interest can be extracted from the farm accounts, but that which is of fundamental importance is the breakdown of the cost of production per unit.

As stated in the last edition of this report, detailed accounts were maintained from the 1st July 1956. Professional guidance was not sanctioned and could not therefore be obtained until September 1958. The records which were taken subsequently, on a revised basis with the assistance and advice provided by the Accountants, have ensured that the figures compiled during the 1958/59 season were completely reliable and accurate in the requisite details for a proper analysis of farm operations. It is now possible, therefore, to publish the analysis of the production costs for 1958/59 and compare the summary with those of the previous two years.

In order to yield all the information of which they are capable such accounts require a detailed review. Such would be out of place and too lengthy for inclusion in this report. The advice and assistance of an Agricultural Economist is being arranged in order to publish a review of the economic features of these accounts. Meanwhile, those interested in obtaining further information concerning these accounts will be welcome to do so from the Farm Manager of Rukera.

(1) *Sales*

In 1958/59 22.675 tons of clean coffee yielded £9,508.8 or £419.35 per ton, after deducting curing and selling charges. The average yield of clean coffee was 5.5 cwt. per acre from 82.4 acres (excluding seed production areas). Clonal plots of 5.0 acres produced 6,196 lb. of seed parchment to the gross value of £2,323.

(2) *Cost of Production*

Table XCI shows the cost of production for each of the past three seasons, expressed as crop expenses per ton (the components of which are enumerated in Table XCIII), the estate maintenance, the overhead expenses and depreciation, as cost per acre and per ton.

It will be observed that the cost of estate maintenance was reduced appreciably during 1958/59. This is due to lower costs of weeding, pest and disease control and a lower cost of fertilizers. Similarly, the charge to overhead expenses has fallen, due to a greater acreage of coffee and economies made in most of the various components which comprise overhead charges. In this connection it is pertinent to note that the net profit from coffee shows much variation in the three years, viz:

1956/57: £8,465.7 from 74 acres or £114.4 per acre.
1957/58: £10,355.8 from 78 acres or £131.5 per acre.
1958/59: £5,235.5 from 87.4 acres or £59.9 per acre.

It should not be inferred from these figures that the reduction in costs was responsible for a lower profit margin in 1958/59, but it is manifest that economies made in operation were justified in view of the prospect of a smaller profit margin.

(3) *Cost at Varying Levels of Production*

On the basis of the costs calculated for the 1958/59 season it is possible to compile a table of comparative costs at varying levels of production, as shown in Table XCII, which illustrates the obvious fact of the economic advantage of a high level of yield.

(4) *Analysis of Crop Expenses and Estate Maintenance Costs*

As a result of the revised method of accounting with full supporting data, it was possible to compile a complete and accurate breakdown of operation costs for the year. These are shown in Table XCIII.

Whilst it is not proposed to review these figures here, an explanation of the nature of some of the heads is apposite. Under Crop Expenses the meaning of the terms used is as follows:

Transport=Moving cherry from field to factory.
Factory Expenses=Labour in factory and on drying grounds.
Upkeep Machinery=Renewals and repairs to plant plus running cost.
Drying Lines=Renewals and repairs of tables and trays plus maintenance.
Supervision=Supervisors' wages in factory and drying grounds.

Under Estate Maintenance the terms used are as follows:

Weeding/Cultivation=All weeding and cultivation by hand or tractor.
Couch Control=Hand digging exclusively.
Pest Control=Cost of chemicals and application, for control of Antestia and Leaf Miner chiefly.
Disease Control=Anti-Leaf-Rust spraying.
'Tonic' Spraying=One copper spray in May, with nitrogen and magnesium fertilizers.
Fertilizing=Nitrogen and magnesium fertilizers only.
Mulching=All costs of carting and laying, but excludes costs of growing and cutting the grass.
Irrigation=A very small area irrigated as a test.
Soil Conservation=Upkeep of terraces, wash-stops and road drains.
General Transport=Miscellaneous tractor transport.
Sundry Expenses=Ancillary estate maintenance.
Replanting Preparation=Cost of uprooting and preparation of Plot 12 for replanting.
Napier Grass=Cost of growing and cutting the grass.

TABLE XCI

Cost of Production

	1958/59 Acreage—82.4 Crop—22.675 tons. Yield per acre: 5.5 cwt.		*1957/58 Acreage—78 Crop—29.85 tons Yield per acre: 7.6 cwt.*		*1956/57 Acreage—74 Crop—28.40 tons Yield per acre: 7.6 cwt.*	
	Per acre	*Per ton*	*Per acre*	*Per ton*	*Per acre*	*Per ton*
(a) Crop Expenses	—	£ 55.08	—	£ 49.51	—	£ 63.72
(b) Management Commission	—	£ 9.93	—	£ 17.70	—	£ 14.79
(c) Estate Maintenance	£ 21.27	£ 77.34	£ 28.52	£ 75.05	£ 27.25	£ 71.71
Overheads	£ 30.48	£110.83	£ 45.71	£120.28	£ 43.32	£114.00
Depreciation	£ 11.05	£ 40.18	£ 6.50	£ 17.10	£ 6.38	£ 16.78
	£ 62.80	£293.36	£ 80.73	£279.64	£ 76.95	£281.00

TABLE XCII

Cost at Varying Levels of Production. 1958/59 Crop. Cost per Ton

Yield per acre	*3 cwt.*	*4 cwt.*	*5.5 cwt.*	*6 cwt.*	*7 cwt.*	*8 cwt.*	*9 cwt.*	*10 cwt.*
Crop Expenses	£ 55.08	55.08	55.08	55.08	55.08	55.08	55.08	55.08
Management Commission	£ 9.93	9.93	9.93	9.93	9.93	9.93	9.93	9.93
	£ 65.01	65.01	65.01	65.01	65.01	65.01	65.01	65.01
Maintenance	£141.46	106.35	77.34	70.90	60.77	53.17	47.26	42.54
Overheads	£203.21	152.40	110.83	101.60	87.05	76.20	67.74	60.96
Depreciation	£ 73.66	55.25	40.18	36.83	31.57	27.62	24.55	22.10
	£483.34	379.01	293.36	274.34	244.40	222.00	204.56	190.61

TABLE XCIII

Crop Expenses Analysed 1958/59 Crop (22.675 tons)	*Total*	*Cost per ton*
Picking	10,945.34	482.70
Stripping	1,176.16	51.87
Transport	266.63	11.75
Factory Expenses	4,757.51	209.81
Bags and Twine	1,460.46	64.40
Transport to Mills	914.84	40.34
Upkeep Machinery	2,810.50	123.95
Drying Lines	737.76	32.53
Supervision Wages	1,483.44	65.42
Water Factory	325.00	14.33
Sundry Expenses	102.09	4.50
	Shs. 24,979.73	1,101.60

Estate Maintenance 1958/59 Crop (87.4 acres)	*Total*	*Cost per acre*
Weeding/Cultivation	5,444.28	62.2
Couch Control	1,066.33	12.2
Pest Control	1,499.16	17.2
Disease Control	3,807.80	43.6
'Tonic' Spray	1,816.98	20.8
Fertilizing	4,585.69	52.5
Mulching	4,300.36	49.2
Pruning	2,793.66	32.0
Handling	1,274.33	14.6
Irrigation	259.11	3.0
Soil Conservation	656.31	7.5
Tools and Equipment	164.00	1.9
General Transport	617.31	7.0
Sundry Expenses	1,469.79	16.8
Replanting Preparation	1,985.01	22.7
Napier Grass	5,440.58	62.2
	Shs. 37,180.70	425.4

SUBSTATIONS

Satisfactory progress was made in developing the newly established substations at Kisii, Meru, Upper Kiambu and Koru. The field investigational programme at these stations was advanced a stage further during the year, to the point where the number and range of field trials are approaching the planned capacity of each station. At Kitale the programme has been revised during the past two years, the revision comprising the termination of old trials which have yielded their conclusions, the re-planting of several blocks of coffee and the inception of new experiments.

The experimental results from all substations are included in the chapter on Field Investigations.

Kitale Experimental Station

1959-60 Crop

Rainfall: 1.159 to 31.12.59	Inches	34.61
Acreage in production		11.00
Clean coffee (tons)		3.14
Mbuni (lb.)		1,166

Classification	*lb.*	*Percentage*
Class 5	3,449	49.0
„ 7	2,108	30.0
„ 9	9	0.1
„ 10	1,079	15.3
„ 11	189	2.7
„ 12	175	2.5
„ 13	31	0.4
	7,040	100.0

In addition to the above experimental samples amounting to one tenth of the crop from two acres were extracted and 957 lb. of seed were produced from the bearing acreage.

The year's rainfall was eleven inches below average, owing to relatively dry weather from May to September which adversely affected crop maturation and quality.

The quality of the season's crop cannot be adequately assessed since all parchment was bulked for milling. Generally the level of yield was much higher than the previous year (at approximately 7 cwt./acre), except in the variety trial where the crop was affected by Leaf Miner and Coffee Berry Disease.

The yield results recorded from trials are included in the chapter on Field Investigations. On the Elgon trials the treatments were applied for the first time during March 1959. One of the three trials was recorded whilst the others, being young trees, were not yet in bearing.

Development

The remaining development works planned were undertaken and mainly completed during the year, viz:

The coffee factory design was modified: a pre-grading screen and electric motor were installed. The drying ground was re-sited near the factory and the tables renovated. Maize and fertilizer stores were converted into living quarters for labour and assistants. Boundary fences were constructed around all coffee plots.

Upper Kiambu Substation

The development of the station was brought to completion during the year with the erection of a small pulpery and weighing room, a garage/implement shed and store. A drying ground for experimental samples was made and racks for trays erected. We are indebted to Yara Estate for solving the problem of water supply to the station, previous attempts to obtain a satisfactory supply having failed.

The field experiments, which were laid down early in 1959, were maintained and recorded. The results accruing from these and the variety trials at Kentmere Estate are reported under Field Investigations.

Koru Substation

Development has proceeded satisfactorily, despite setbacks, since the farm was taken over at the end of January 1959. Unseasonable rainfall at this season hindered land clearing and preparation, but thirty acres had been cleared by April and seventeen of these acres were planted to coffee. Five acres of riverine forest were cleared to allow a coffee nursery to be established. Abnormally dry weather during June and July adversely affected both transplants and nursery seedlings.

Three acres of derelict coffee were cleared, stumped and regenerated with a new cycle of suckers. The main problem in rehabilitating the arable land has been eradication of couch; this has been overcome by the use of hand-forking and Dalapon spraying.

A second area of twenty-five acres of arable land was cleaned later in the year and a small herd of store bullocks was purchased to graze the hill slopes.

Recently the farm has been surveyed by the Soil Conservation Service and, with the aid of maps thus produced, use of the arable areas has been planned in detail.

Meru Substation

Very satisfactory progress has been made in the station's development during the year. As elsewhere the prolonged drought in the middle of the year proved a serious handicap in establishing new plantings. Several new trials, coffee plots for trial purposes and a seed garden were planted on the station and five variety trials were laid down elsewhere in the district.

Shelter belts, Napier grass areas and mulch species for test were planted. Bench terracing and internal fencing was completed. Pastures were cleared, two ley paddocks were broken and planted.

Several ancillary buildings were erected, viz: two lock-up garages, an implement shed and fuel store; cattle shed, calf pens and covered yard, to which a piped water supply was laid.

Livestock purchased comprised ten Boran heifers, a small number of native ewes and a Karakul ram.

Experimental work was confined to recording off-station variety trials in the district and three 'tonic' spray trials.

Kisii Substation

Very good progress was made in the development of the station during the year. The coffee acreage was extended by 8.6 acres to bring the total planted to 17.7 acres. Further mulch grass areas of Napier and Nandi setaria were planted.

The programme of investigation was initiated with the laying down of five comprehensive field experiments on the station; the Rust Exposure trial in the district was extended. The variety trial on the station and variety trials in the district were recorded.

The station's buildings were extended by the addition of an implement shed and store, two assistants' quarters, propagation frames for cuttings and, at the end of the year, work commenced on the building of the coffee factory and water storage tank.

As in Meru the Officer in Charge of the substation is responsible for all coffee experiments in the district. In this connection Mr. Reynolds was responsible for collection of K.7 seed from selected plots in the district and participated in a Leaf Miner survey and an Antestia control experiment.

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